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ORIGINAL ARTICLES.

I.—A Giant Sub-Fossil Rat from Madagascar, *Myoxyctes raptus*,[1] gen. et sp. nov.

By Dr. C. I. Forsyth Major, F.Z.S.

AMONGST the vertebrate remains which I found in the marshes of Sirabé (Central Madagascar), a large Rodent is represented by two right ossa innominata, one of which (B.M. M 7085) is fairly complete, only the free portion of the pars dorsalis of the ischium being broken off.

The very elongate, comparatively narrow ilium, divided pretty equally by the crista lateralis into a dorsal and a ventral portion, shows that we have to deal with a muriform member of the Rodentia; it comes very near in its general form to the same bone of the Malagasy genera of rats *Nesomys*, *Gymnuromys*, *Eliurus*, and *Hypogeomys*; in *Brachyuromys* the long axis of the ilium is more straightened. The single tuberculum iliopectineum (= iliopubicum) for the insertion of the psoas minor is enormous, and the spina ventralis posterior (= anterior inferior of man) is likewise very strong.

The conformation of the os pubis, however, is markedly different from that of the genera above-mentioned; its pars anterior is very long and directed more decidedly backwards, and the symphysis is quite minute. This is the shape of a vole's pubis, and in a general way of all fossorial Muridæ and Rodents generally,[2] so that I do not hesitate in assigning the fossil to a highly fossorial Rodent.

The length of the fossil innominatum is 134·5 mm.; that of the bone in a *Nesomys rufus* = 41 mm.; the skull of the latter has a basal length of 39·5 mm., the absolute maximum length—front of nasals to occiput—being 49 mm. The approximate corresponding measurements of the cranium of the new genus may therefore be

[1] *rapeto* is the Malagasy word for 'giant, uncanny.'

[2] Cf. in Tullberg, "Über das System der Nagethiere" (1899), the figure of the innominatum of *Nesomys* (pl. 32, figs. 11, 12), and those of the genera of fossorial Rodents, viz., *Spalax* (figs. 13, 14), *Ellobius* (figs. 15, 16), *Arvicola amphibius* (figs. 17, 18), *Hesperomys* (figs. 19, 20), *Geomys* (figs. 27, 28), *Georychus* (pl. 31, figs. 1, 2), *Otomys* (figs. 19, 20), *Haplodon* (pl. 33, fig. 8), *Pteromys* (figs. 23, 24),

calculated at 129·5 and 160·7 mm. respectively. In the largest known recent Rat, the *Phloeomys* of the Philippines (B.M. No. 97.3.1.17), the skull has a basal length of 80 and maximum length of 90 mm.

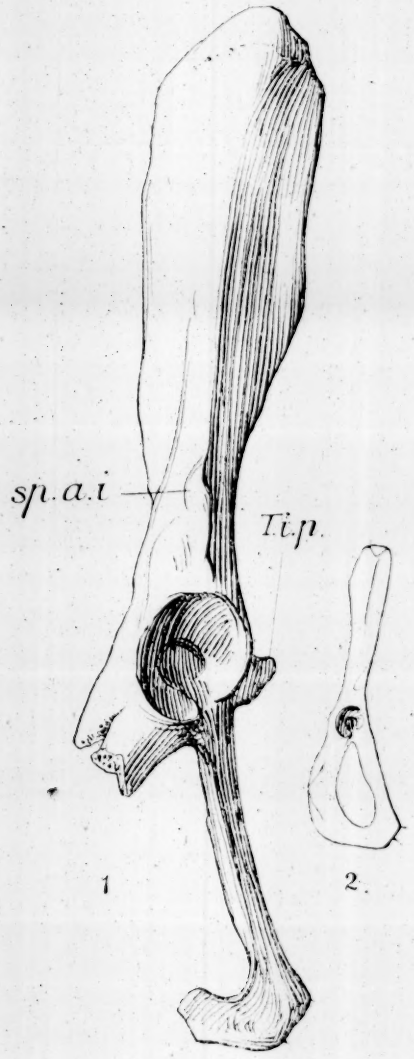


Fig. 1.—Right innominate bone of a giant sub-fossil Rat, from Sirabé, Central Madagascar, *Myoxycetes capeto*, gen. et sp. nov. *sp.a.i.* spina anterior inferior ilei; *Ti.p.* tuberculum iliopectineum.

Fig. 2.—The same bone of *Arvicola amphibia*.

Both figures are natural size.

II.—On the Age of the Reptile Faunas contained in the Magnesian Conglomerate at Bristol and in the Elgin Sandstone.

By Friedrich Baron Huene, D.Sc., Tübingen, Germany.

ACCORDING to Etheridge (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pp. 174–192) the Magnesian Conglomerate at Bristol is of the same age as the German Muschelkalk, but Moore (Quart. Journ. Geol. Soc., vol. xxxvii, 1881, pp. 67–82) was of opinion that it was Rhætic. Since that time no special paper on the subject has been published, but now the present writer has been able to find some new evidence.

The reptilian remains of the Magnesian Conglomerate comprise four species—

Thecodontosaurus antiquus, Morris.
T. cylindrodon, Riley & Stutchbury.
Palæosaurus platyodon, Riley & Stutchbury.
Rileya bristolensis, Huene.

Thecodontosaurus antiquus and *T. cylindrodon* are very primitive theropodous dinosaurs (see Seeley, Ann. Mag. Nat. Hist., vol. xv, 1895, pp. 102–132, and Huene, Zeitschr. d. deutsch. geol. Ges., 1895, p. 349). A full description will soon appear in Huene, "Die Dinosaurier der europäischen Triasformation" (Pal. u. geol. Abh., suppl Bd., G. Fischer, Jena). The tooth of *Palæosaurus platyodon* belongs probably to a Phytosaur. The name *Palæosaurus* is preoccupied by Geoffrey, 1831. The bones of *Rileya bristolensis* (Huene, Pal. u. geol. Abh., vol. vi (x), 1902, pp. 62–63) belong to a Phytosaur too. Now it seems to the writer not impossible that they came from the same animal, so that the tooth, if that be the case, should be named *Rileya platyodon*, R. & St., sp.

The small tooth figured by Murchison & Strickland, 1837 (Trans. Geol. Soc., vol. v, pl. xxviii, fig. 7*a*), is *Thecodontosaurus antiquus*; and the writer found a short time ago in the Warwick Museum that vertebræ figured by Huxley (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pl. iii, fig. 9) and Owen (Trans. Geol. Soc., vol. vi, 1842, pl. xlv), and some other bones from the Lower Keuper Sandstone of Coton End Quarry, near Warwick, belong to the same species. Moreover, the tooth of *Thecodontosaurus cylindrodon* figured by Huxley (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pl. iii, fig. 4), and another one figured by Owen (Trans. Geol. Soc., vol. v, 1837 (1840), pl. xxiii, fig. 9), also from Coton End, really belong to that species. And as *T. antiquus* and *T. cylindrodon* occur in the Magnesian Conglomerate and in the Lower Keuper Sandstone both strata must be of the same age.

Concerning the Elgin Sandstone, the writer at first (Pal. u. geol. Abh., vol. vi (x), 1902, p. 74) divided it into the Permian *Elginia*-sandstone (Cuttie's Hillock) and the Triassic *Stagonolepis*-sandstone (Lossiemouth, Spynie, and Firdrassie), according to their respective faunas. Two years later Boulenger adopted the same classification (Proc. Zool. Soc., 1904, vol. i, pt. 2, pp. 470–487) and applied the term *Gordonia*-sandstone to the Permian beds. The only reptile of the *Stagonolepis*-sandstone occurring also elsewhere is *Hyperodapedon Gordoni*, Huxley. It is one of the characteristic fossils of the Lower

Keuper Sandstone, having been found at Warwick (Coton End), Bromsgrove, and Otter River, Devonshire. So the *Steganolepis*-sandstone of Elgin is also of the same age as the Lower Keuper Sandstone.

But now, what is the age of the Lower Keuper Sandstone? Two of its fossils are also found in the German Trias, namely, *Mastodonsaurus giganteus*, Jäger, in the German Lettenkohle, and *Equisetum arenaceum*, Jäger, in the German Lettenkohle and Schiefsandstein. The numerous other (autochthonous) Labyrinthodont species (seven) proves also the age of the Lower German Keuper. So we conclude that the fossiliferous parts of the Lower Keuper Sandstone (Upper [and Middle?]), the Magnesian Conglomerate of Bristol, and the *Steganolepis*-sandstone are of Lettenkohle age. Therefore the Upper Keuper of England is of the same age and extent as the German Keuper above the Lettenkohle; while the English Bunter and perhaps the lowest part of Lower Keuper Sandstone are deposits contemporaneous with the German Buntsandstein + Muschelkalk.

III.—Note on Two Sections in the Lower Keuper Sandstone of Guy's Cliff, Warwick.

By Friedrich Baron Huene, D.Sc., Tübingen, Germany.

In October, 1907, the Rev. J. Magens Mello, F.G.S., kindly took me to the Lower Keuper section on the bank of the Avon at Guy's Cliff, near Warwick. These sections are very instructive in a special sense.

It has been asserted more than once that the English Trias is a desert formation, but I am of opinion that neither the Bunter nor the Keuper can be thus explained. How could the presence of *Equisetum*, of Sharks and Ganoids, and of the many Labyrinthodonts and Rhynchosaurians in the Lower and Upper Keuper, in this case

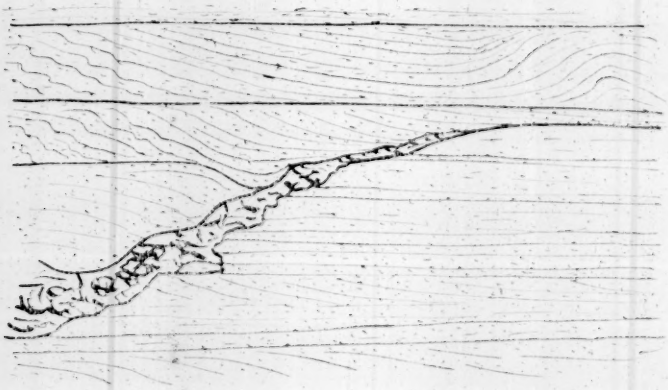


Fig. 1.—Section in the Lower Keuper Sandstone on the rocky bank of the Avon below Guy's Cliff House, Warwick. (The dotted spaces are sandstones; the breccia is strongly marked.) (Diagrams by the author.)

be explained? In considering the formation of the Keuper strata it should always be imagined that a great continent extended from England to America, but a brackish sea and swamp from England to Eastern Germany as far as the Scandinavian, East Prussian, and Bohemian borders, where another great northern continent began and extended eastwards. England was thus the western zone of gulfs and brackish swamps, but in the west was the great Atlantic continent, probably with great sand-masses from the weathered Armorican Alps.

In one of the outcrops of the Keuper Sandstone at Guy's Cliff, below the house of Lord Algernon Percy, on the bank of the Avon (Fig. 1), some horizontal laminated strata of sandstone have obviously been eroded and covered over by a conglomerated and brecciated mass, and after that this little valley was again filled up by cross-bedded sand.

The other section higher up and opposite the house (Fig. 2) shows several strata of sandstone, between which are thin layers of marl and conglomerate. It is very interesting to observe how the uppermost of these thin marl-layers is crushed. It cannot possibly be the natural bedding, but the marl is squeezed by the heavy overlying sand-mass, which was probably a dune with a moving line of the greatest heaviness (the vertical line of the dune).

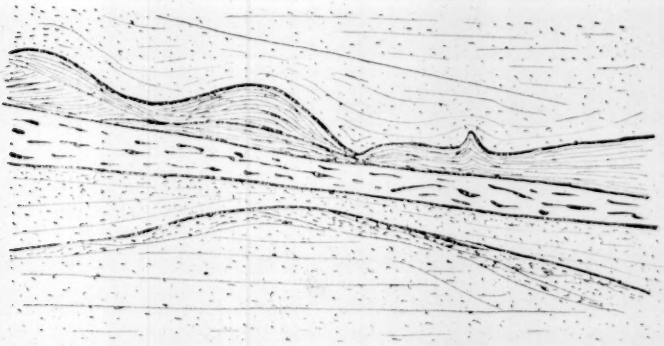


Fig. 2.—Small section in the Lower Keuper Sandstone on the rocky cliff opposite Guy's Cliff House, Warwick. (The dotted spaces are sandstones, the hatched ones are marls, the breccia is strongly marked.)

The same is still better visible in the largest quarry at Bromsgrove[1] (Fig. 3). There are overhanging folds of shale pressed into the thick masses of sandstone. This cannot be produced otherwise than by pressure in one direction, and that again can only be the result of advancing dunes, because it is, of course, not a tectonic pressure.

Dunes and strongly and quickly eroding waters are found together either in deserts or near the border of the sea. It cannot be the first in the case of the Lower Keuper Sandstone, because this sandstone contains *Acrodus*, *Hybodus*, *Semionotus*, and *Dictyopyge*. The sand-masses must therefore be dunes near the shore. In Coton End Quarry, near

[1] Mr. L. J. Wills, M.A., kindly guided me to this interesting section.

Warwick, a tooth of *Ceratodus lævissimus*, Miall, has been found, so that fresh water, probably a river, must have been there. The dunes were, perhaps, not only sea-dunes but also sand-waves advancing

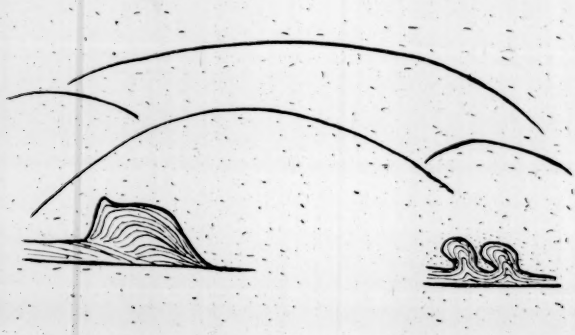


Fig. 3.—Large section (much reduced) in the largest of the quarries near Bromsgrove, Worcestershire. (The dotted spaces are fossil sand dunes, the hatched spaces are shales in two different corners of the same great cliff.)

eastwards from the great and perhaps partly desert-covered Atlantic continent to the border of the salt-swamps and brackish bays of the Anglo-German region.

IV.—Flowing Wells and Sub-Surface Water in Kharga Oasis.

By Hugh John Llewellyn Beadnell, Assoc.R.S.M., F.G.S.

(PLATE VII.)

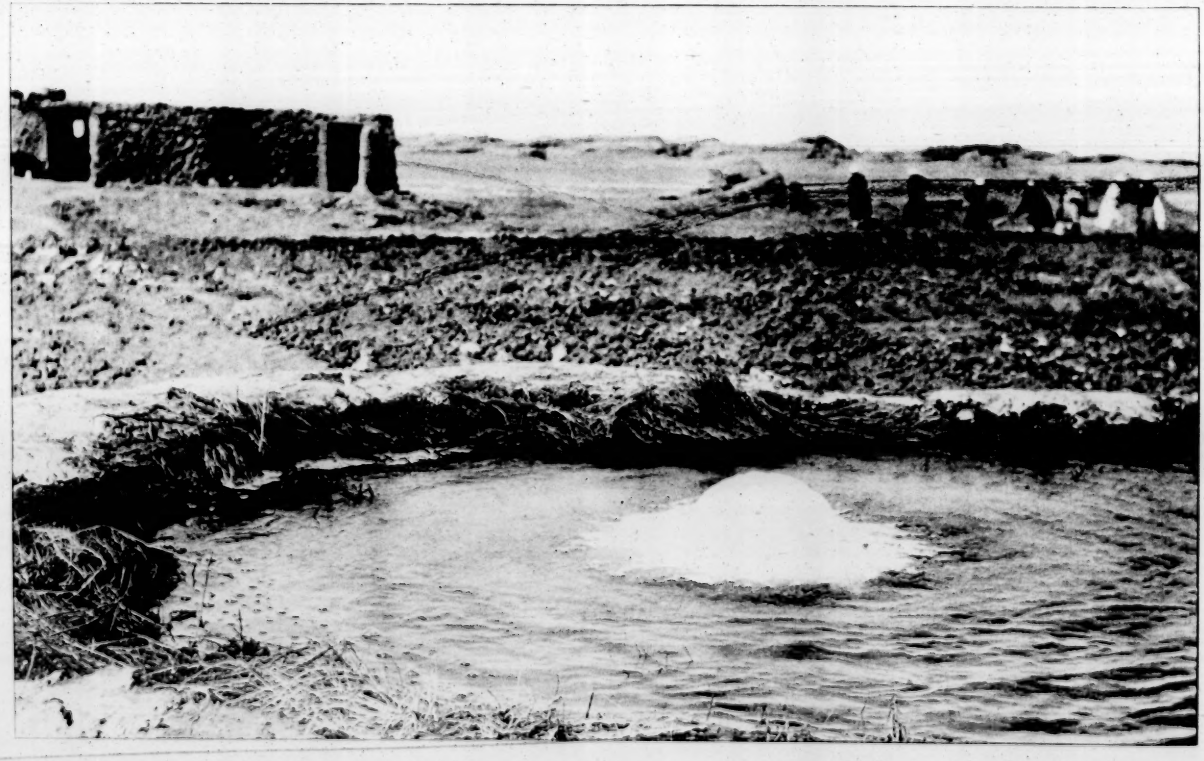
(*Concluded from the February Number, page* 57.)

THE possibility of obtaining, under certain conditions, flowing wells from these sandstones[1] has been brought to my notice by the discovery that in the neighbourhood of El Dêr, on the east side of the depression, flowing water is obtainable from comparatively shallow wells sunk on the crest of the anticlinal fold, which runs north and south through that district, through the red shales to the underlying surface-water sandstone (see section).[2] I am unable to speak positively of the original depth of the ancient wells in this district, but when one of those to the north of El Dêr was taken in hand, cleaned out and cased, flowing water was met with at a depth of 65 metres, below which untouched ground was struck. The flow increased on drilling a few metres into the sandstone rock below, and the bore has now given a fairly steady discharge of about 40 gallons per minute for over twelve months.

The water appears to be derived from the surface-water sandstone, though here on a line of disturbance it would not be safe to disregard the possibility of the presence of fissures through which the water might rise directly from the artesian-water sandstones below. If, as appears to be the case from the depth of the bore and position of the

[1] See *ante*, p. 56.

[2] *Ante*, p. 55.



View of Flowing Well (Bore No. 37), Kharga Oasis, Libyan Desert, Egypt.

strata, the water is derived from the surface-water sandstones, the explanation may lie in the general east and west dip, resulting in a difference of level of the sandstones here and in adjacent districts—a difference which may be sufficient to furnish the necessary working head, which, as has been suggested by Cridler & Johnson, may be the only essential requirement for an artesian flow.[1]

Artesian-water Sandstones.

The source of the great majority, if not of all, the flowing wells of the oasis is the group of sandstones underlying the "impermeable grey shales." Needless to say, the beds of the series are nowhere visible to the eye, but judging by the samples obtained from the bores put down under my supervision during the last two years they do not differ in general characters from the sandstones just described. Throughout the area over which our operations have extended, no well-defined or persistent argillaceous bands have been met with, though the deepest bores have been carried to a depth of 122 metres (400 feet) below the junction of the sandstones, with the confining shales above. The beds vary considerably in coarseness and porosity, in hardness, and in the amount of cementing material between the individual grains of the rock, all of which characters have a marked influence on their capacity as water-carriers. Thin seams of lignite, frequently associated with bands of iron pyrites, testify to the conditions under which these beds were originally laid down.

The Artesian Wells.

As no very reliable data concerning the few native wells which have been sunk in recent times are available, it will be more satisfactory, in describing the wells themselves, to confine our attention to those which have been drilled on the headquarters area during the last two years and of which accurate and reliable records have been preserved.

The area around headquarters is one of the few large districts entirely devoid of old wells and traces of ancient cultivation. A combination of circumstances appears to have led the ancients to regard this area unfavourably: firstly, the general elevation is comparatively high, meaning small flows from wells of ordinary depth; secondly, the 'soil' is heavy, necessitating a considerable expenditure of time and labour to bring it into good growing condition; and thirdly, and probably most important of all, the presence of a copious supply of surface water, which would have greatly hampered, if not made impossible, the old system of well-sinking.

It may be assumed, therefore, that owing to the entire absence of both ancient and modern wells the water-sandstones of this district were practically fully charged at the time the first bore was sunk.

The junction of the artesian-water sandstone with the grey shales above is usually fairly abrupt, the first flowing water being obtained as soon as the bore strikes the top of the sandstone. Although

[1] A. F. Cridler & L. C. Johnson, "Underground Water Resources of Mississippi": Water Supply and Irrigation Paper No. 159, United States Geological Survey publications.

different layers of the sandstone vary greatly in water-holding capacity, there is almost certainly an intimate connection between all parts of it, as no definite bands of shale or other impervious strata have been met with. Where alternating shales and sandstones occur at or near the junction the latter are usually charged with water under feeble pressure, yielding flows at the surface of from one to five gallons a minute. On drilling into the sandstone proper, increments in the flow are generally obtained at fairly frequent but very irregular intervals of depth. At times the flow is seen to increase slowly but steadily, while a particularly porous bed is being passed through: at others the rate of increase is so rapid as to suggest that a fissure filled with freely flowing water has been struck. Hard bands of sandstone, acting locally as confining beds, frequently overlie the best water-carrying layers; while loose and uncemented sands, which continually 'cave,' that is, run in on all sides, and which form one of the greatest difficulties with which drillers have to contend, may be encountered at any time, though they do not seem, as might be expected, to coincide with marked increases of flow.

Of twenty bores finished in this district none have failed to strike water, though three have yielded such small flows that they must be regarded as comparative failures; of the remaining seventeen the average flow on completion was approximately 100 gallons per minute, the maximum being 350 and the minimum 65 gallons per minute.

By far the most important factor determining the volume of flow is the absolute ground-level at the mouth of the well. The floor of the oasis in the district under description lies between 53 and 61 metres above sea-level,[1] the general slope being to the west in the opposite direction to the dip of the water-bearing sandstones. Although the actual difference of level is so little, amounting only to 7 or 8 metres, the difference of flows from wells of equal depth on either side of the area averages fully 100 per cent. This indicates that we are on this area very near the static head or limit to which water will rise from bores of this depth, and this is borne out by the observed pressures, which even in one of the best wells when first completed and flowing about 217 gallons per minute only amounted to just over 8 lbs. to the square inch.

In the neighbouring oasis of Dakhla there are a number of wells whose temperatures are from 90° to 100° F.; some few even exceed the latter figure, the highest temperature recorded being 105° F. in Bir el Dinaria, a well sunk fifteen years ago and the deepest and most northerly bore in the oasis. The temperature of the Kharga wells average considerably less; of thirteen new bores measured in the headquarters district two have temperatures of 87° F., the remaining being one degree lower.

One of the most noticeable features of the wells is the highly effervescent character of the water as it reaches the surface. In some cases it resembles the contents of a newly opened bottle of aerated water, in others the gas reaches the surface in a slow continual

[1] The datum used being a point on the Western Oasis Railway, the value of which must be regarded as approximate only.

succession of large bubbles. Analysis shows the gas to consist almost entirely of nitrogen, only small quantities of oxygen and CO_2 being present. Mr. Garsed's results are as follows:—

Headquarters District: Bore No.	1	2	3	4	5	6
Carbon dioxide	1·6	1·6	3·6[1]	1·8	1·2	1·2
Oxygen	0·8	nil	0·8	0·6	0·3	nil
Ethylene and unsaturated hydrocarbon	nil	nil	nil	nil	nil	nil
Carbon monoxide	nil	nil	nil	nil	nil	nil
Residual gas—Nitrogen	97·6	98·4	95·6	97·6	98·5	98·8

It was estimated by rough experiment that the volume of gas issuing from Bore No. 1 (diameter of bore 4¼″) amounted to half a pint a minute.

The quality of the artesian water seems to be in all respects excellent, and when taken direct from the outlet of a cased well has for domestic purposes the advantage of being free from all danger of contamination. Analyses of the waters of four of our bores show the total dissolved solids to range from 43 to 47 parts per 100,000, equivalent to from 30 to 33 grains per gallon. The water is generally slightly ferruginous even in new bores, while in one or two of the ancient wells it is so highly charged with ferric oxide that thick deposits of ochre have been formed along the channels.

Analyses of Typical Artesian Water of Kharga Oasis.

Headquarters District: Bore No.	1	2	5	6
Total solids, grains per gallon	33	30	32	32
Composition of dissolved salts, per cent.				
Silica	4·2	4·5	4·6	3·4
Ferric oxide	1·7	0·8	1·2	1·2
Lime	6·5	7·6	5·4	5·6
Magnesia	2·9	3·1	2·7	3·8
Sulphuric anhydride	4·5	4·9	4·4	4·4

[1] Mr. Garsed informs me that the CO_2 figure of Bore No. 3, which appears comparatively high, may be due to experimental error.

General Considerations of the Water-supply as a whole.

As I hope shortly to publish the results of experiments carried out to determine the mutual influence of wells, it need only be remarked here that the sensitiveness of any one well to its neighbours is far greater than has, I believe, been generally supposed. For instance, the shutting down of a flowing or the opening of a closed well will produce a most marked effect on a neighbouring well within the short space of sixty minutes, even when the intervening distance is over 500 metres. The degree of influence is especially dependent on the amount of difference between the depths, discharges, and surface-levels of the bores.

When drilling was first commenced in the headquarters district the bores were placed at an average distance apart of 500 metres; the circumstances of drilling, however, led to there being a great variation in the depths of the bores, with the result that those of comparatively shallow depth and those situated on comparatively high ground were adversely affected by the deeper and more favourably placed ones; to lessen the effects of this extreme sensitiveness the average distance between the bores has since been considerably increased.

All bores show a marked decline in discharge for some time after completion, when they settle down to a fairly steady flow, or at least to a flow which decreases at a constantly diminishing rate, except when affected by new bores subsequently sunk in the vicinity. The same point is brought out by observing the extent and rate to which the pressure and flow can be increased by the temporary closing of a bore. Experiments show that a flow may be augmented by as much as 75 per cent. as the result of closing a bore for five days, the increased discharge falling to its normal twelve hours after reopening.

Data are as yet far too insufficient to warrant an attempt to calculate the supply which can safely be drawn from a given area without unduly reducing the pressure and lowering the water-level. In some parts of the oasis there are bores many hundreds of years old still pouring forth their hundreds of gallons a minute; such wells are probably situated in particularly favourable positions or have been exceptionally fortunate in striking large fissures. There are at the same time hundreds of wells which have ceased running, either through local exhaustion of the sandstones or through failure to keep the channels open, or through a combination of both circumstances. In many instances new bores sunk in the immediate neighbourhood of old wells, some of which were completely extinct while others were yielding feeble flows only, have produced strong discharges of considerable volume.

At the present day there are about 230 native owned flowing wells in the oasis of Kharga, yielding a total discharge of some 295 'qirats.' The output of wells is for purposes of taxation determined in a very rough and ready manner by measuring the depth of water passing over a weir of definite breadth fixed in the stream. The discharge is reckoned in qirats, a qirat being a water-section of 64 square centimetres. As the velocity of the stream is not taken into account the qirat has a very variable value, low for small and high for large flows, the result being that the smaller wells are being taxed as much

as 50 per cent. higher than the large ones. In order to obtain the average value of the qirat for streams of different size I had thirteen of our new bores, with discharges varying from 23 to 233 gallons a minute, measured by the local native measurers by their own methods, I myself making direct measurements immediately afterwards. It was found that below 2 the qirat has a value of 22 gallons per minute, from 2 to 4 of 26 gallons per minute, from 4 to 5 of 33 gallons per minute, and from 5 to 6 of 38 gallons per minute.

Applying these values as far as possible to the old wells and adding the known discharge of the score of new bores, we shall not be very far from the truth if we estimate the total discharge of the whole of the Kharga wells at 8,000 gallons a minute or 11½ million gallons (53,000 cubic metres) a day.

The numerous and often extensive remains of temples, forts, and villages in many parts of the oasis, the abundant traces of ancient cultivation, and the hundreds of old sanded-up wells have given rise to a widespread belief that the oasis was in olden times far more thickly populated and better watered than at the present day. That this was to some extent the case is not to be gainsaid, but it must not be forgotten that the remains in question belong to successive generations, and that there is as yet no evidence to enable us to determine how much of this land or how many of these wells were in use at one and the same time.

When one considers the vast areas under which the water-bearing sandstones are known to extend, and the comparatively small extent of country over which the existing wells occur; when it is remembered that as yet the deepest bores have only penetrated the water-bearing beds to a depth of 400 feet; that the existing total discharge is mostly made up of insignificant flows from a great number of very ancient and comparatively shallow wells, which for centuries have been subject to gradual decay; that so far as observed, the flows obtainable increase in volume as deeper beds are struck; it does not seem unreasonable to assume that the total discharge could be very much increased, though to what extent this could profitably be done is another question and one with which it is not the province of this article to deal.

Until such time as our knowledge of the region to the south of the oases enables us to do better than label the whole country "Nubian sandstone," and until more information is available as regards the relative levels of the oases and different parts of the Nile Valley and Libyan desert as far south as the more elevated regions of Kordofan, Darfur, and Tibesti, any attempt to explain the origin of the artesian waters of the oases must be regarded as little better than speculation. Possible sources of origin lie in the rainy districts of the Sudan, in the great swamps of the upper Nile, in the Nile river itself, in past accumulations of water absorbed from the extensive lakes which covered parts of the oases and Nile Valley depressions in the pluvial period which preceded the existing desert conditions. The water may be entirely of meteoric origin, derived from one or other of these sources, or it may be partly of magmatic or plutonic origin, derived from the deeper-seated rocks underlying the country.

It is not possible in the limits of this paper to adequately discuss questions which, as we know in the case of the artesian waters of Central Australia, have given rise to such diverse opinions among well-known professional geologists who have made long and special studies of the subject. It will readily be admitted that the ordinary explanation of the origin and flow of artesian wells in regions of moderate or abundant rainfall, situated in well-defined basins where the exact position, extent, and absorbing capacity of the water-table outcrop can be carefully determined, may be entirely inadequate to account for the flowing wells of vast arid regions like those of Australia and Africa.

It is moreover almost incredible that, where the outcrop of the water-bearing strata is so remote from the wells themselves and the dip over the intervening country so slight, the rise of the water could be due to direct pressure of water flowing downwards through the higher portions of the beds, unless on the supposition of the existence of large and continuous open fissures. Local pressure arising from variation in the level of the water-table in adjacent areas might, however, quite conceivably be adequate to account for the phenomenon, especially if assisted by the presence of large volumes of gas under compression. Much stress has been laid by Gregory and other writers on the pressure of the overlying strata,[1] but if this were sufficient to squeeze water from the pores and crevices of a bed and force it up through hundreds of feet to the surface as soon as a free passage was provided, surely the same pressure would have long ago obliterated all such pores and prevented water from ever having obtained access to the bed in question.

The points to which attention should be directed as likely to throw light on the origin of the oases artesian wells are: the area and position of the outcrops of the impermeable grey shales and the underlying sandstone, and their relations to possible sources of water, whether rain, river, or lake; the nature of the bed of the swamp region of the upper Nile; the amount and distribution of the rainfall of all surrounding regions; the amount of water lost in different reaches of the Nile over and above that which can be directly accounted for by evaporation and by water abstracted for purposes of irrigation; the total thickness of the water-bearing sandstones, and the presence or absence within them of impervious strata; and lastly, the relation of the water-bearing beds to the underlying crystalline rocks.

V.—Windings of Rivers.

By T. S. Ellis.

THE course of rivers cannot be properly understood if regarded as objects complete in themselves. In reality, a river is only a part of a system of channels serving to drain the whole of the area over which it extends, the breadth as well as the length. Of this system the tributaries are an essential part. So, too, valleys and combes

[1] J. W. Gregory: "The Dead Heart of Australia," London, 1906, pp. 288–289.

which still exist but no longer serve for streams, and others altogether effaced, have, in former times, been included in the system. I hold to my belief, recorded nearly twenty-six years ago, that only by taking into account the influence of tributary streams can river-windings be explained, and that the subject is important as "bearing on the formation of warths and the maintenance of navigation channels."[1]

The system of drainage as we see it, a principal channel with tributaries flowing in on either side, is the result of a long process of evolution. When the rainfall began its work of denudation, no turf, nor trees, nor verdure of any kind existed: the rain fell directly on to the surface. Now a very large proportion is either conducted gently down to and into the earth, or fails to reach it at all, passing off by evaporation. According to Reclus ("The Earth") "Becquerel's experiments prove that during heavy rain only $\frac{1}{10}$ of that which falls reaches the ground." At any rate, a much larger quantity of water would, with the same rainfall, have flowed off the surface than now does; and this, I think, fully explains dry valleys and combes, even those of the Chalk hills, such as are now seen.

Whatever the size of the early channels they would certainly be numerous, and, having regard to the uneven surface of an uplifted area, be diverted in different directions. Thus they would meet in loops and form a network which might continue even after a well-defined valley has been formed. Such loops are often seen in the present day. Out of the network the principal line of stream (the river) is selected. Which one this will be must depend on a number of circumstances. A tributary stream coming from a lateral valley would require a channel on that side. Into this, necessarily kept open, streams near the middle line of the valley may flow, and these may attract others, so that, finally, one might be continued in a channel adapted to the needs of the principal stream and of the tributary. Certainly, either the principal stream must be inclined towards the tributary, or the tributary must be extended to the principal stream. In fact, the two often meet in the form of a capital-letter Y, as I illustrated in the paper mentioned by the case of the Severn and Avon at Tewkesbury. A diverted route of the principal stream, more or less circuitous, would render those in a more direct line unnecessary, except only for the area close to them. Denudation, therefore, would not go on in the same degree, and some of the channels would be effaced, wholly or in part.

The process of evolution is, in principle, the same, whether it be in a denudation area or in alluvial soil where the streams not only arrange their own channels but also build up their own banks. The process is well illustrated in the sketch-map taken from an old Baedeker's Guide to the Rhine, Fig. 2, p. 112. The river Ill, which occupies the same valley, is not shown; it is now at the margin on the left side, by the Vosges Mountains. Probably it was once part of the Rhine system which is seen inclining to the right side, that of the

[1] "On some Features in the Formation of the Severn Valley," a paper read before the School of Science Philosophical Society, at Gloucester, on February 7th, 1883. Printed for the Society.

Black Forest. Here, having received a stream coming down from Staufen, it has, in one case, settled into a single channel. The partially effaced loops are seen on the opposite side as streams serving to drain the local area. The river here does not form a sharp curve, it inclines to its tributary, the two resembling the letter Y. The faint upper stroke is, however, on the wrong side; the figure should be held up to the light and viewed from the back; then the resemblance is manifest. If the Rhine valley had been less wide and the country on the margin less mountainous a single river might have sufficed. Then it would have swung from side to side, taking in tributaries on the convexities of great curves. The curved double lines in the figure indicate an artificially regulated channel. The present condition may be seen in the "Karten des Deutschen Reiches," pp. 630 and 643. I discussed the influence which a tributary stream would have in diverting the course of the larger one, supposing it to be straight, in the GEOLOGICAL MAGAZINE for August, 1903, pp. 350–354.

FIG. 1.—River-windings, a relic of an old figure-of-8 looping.

That some relation exists between river-windings and tributary streams seems to be indicated by such facts as the following:—On the Thames, near London, are four well-marked windings near together. Of these, three receive tributaries on their convexities: at Brentford, the Brent; at Hammersmith, the stream now only represented for a short distance by the creek; at Wandsworth, the Wandle. The convexity between Mortlake and Barnes receives no stream now, but a very short channel cut in the alluvium would connect the river with the Beverley brook which, directed due northward along the Combe Valley, turns to the east and falls into the river opposite Fulham. Assuming an old arm of a loop to have been partially effaced, why did the river prefer to "go by the bow" and not "by the cord"? Because the Hammersmith stream required a channel to be kept open

for its use. Here the case differs from that of the 'Oxbows' on the Mississippi. The short route has been abandoned; the circuitous one remains. Mortlake does not mean dead lake in the modern meaning of the word 'lake,' but dead stream.

The Thames also supplies striking instances, on a larger scale, of river-windings, relics of old loopings. At Bray there is a tongue-shaped area of low-lying land bounded, as it projects westward to Waltham, by the 100 feet contour-line, so forming a shallow combe. This, although now occupied by only a small stream, suggests an old arm of the river between Bray and Sonning. Here again the river goes, not "by the cord"—it has deserted that line—but "by the bow" round by Henley and Marlow, receiving the streams which flow down the slopes of the Chiltern Hills, representatives, it may be, of larger ones at an earlier period. In my view, the river adopted for itself the line of channel necessarily kept open by these streams, and so the circuitous rather than the direct route became the permanent course of the river.

Only less manifest is the case of the Wey and Blackwater, separated at a point between Farnham and Aldershot by a slight 'sill' only. The former stream flows in a direction down the line of the Thames to Weybridge, and the latter in a direction up the line of it to join the Loddon in its course to the Thames near Shiplake. As I find, it is far easier to believe that the two streams, so curiously close to each other, were continuous when the river flowed at a higher level and occupied a wider valley, than it is to imagine that the approximation signifies a 'working' or 'eating backwards,' going on towards 'capture' of one by the other, as similar features have been explained. Elbows in two neighbouring streams pointed towards each other also suggest a former union, and, generally, the level of the ground between them does not forbid the supposition. An instance is seen in the Wey and the Mole south of St. George's Hill by Weybridge, and, again, in the Oak and the Childrey Brook by Abingdon. The Thames abounds, all along its course, in interesting features illustrating the Natural-history of rivers and, as I contend, showing the hopelessness of attempting to explain river-windings by theories of reciprocal curves or of relation between extent of curve and velocity or volume of stream.

On the other hand, appearances suggestive of old loopings as the explanation of river-windings are very common. No one accustomed to observe English rivers would be surprised to hear that Fig. 1 represented a mile or so in one of them. It really represents more than 500 miles of the Nile, and is taken from Dr. Budge's Guide to Egypt and the Soudan. It shows, at the upper part, the meeting of the Blue and White Nile by Khartoum. In imagination I filled in the lines so as to make a figure of 8, and then sought for evidence of an old arm of the river to complete the lower loop. The little upward curve at the foot is by Korosko at one end of a valley, 60 miles long, extending southwards up to Bab el (gate of) Korosko. This, with other valleys, seems to afford sufficient evidence of an old looping with the river at the prominence shown (Abu Hamed), 220 miles south from Korosko.

In estuaries the influence of tributary streams can be seen in operation. They divert the low-water channels and, therefore, the deep-water line. This is strikingly illustrated in the Exe, to be discussed in a future paper.

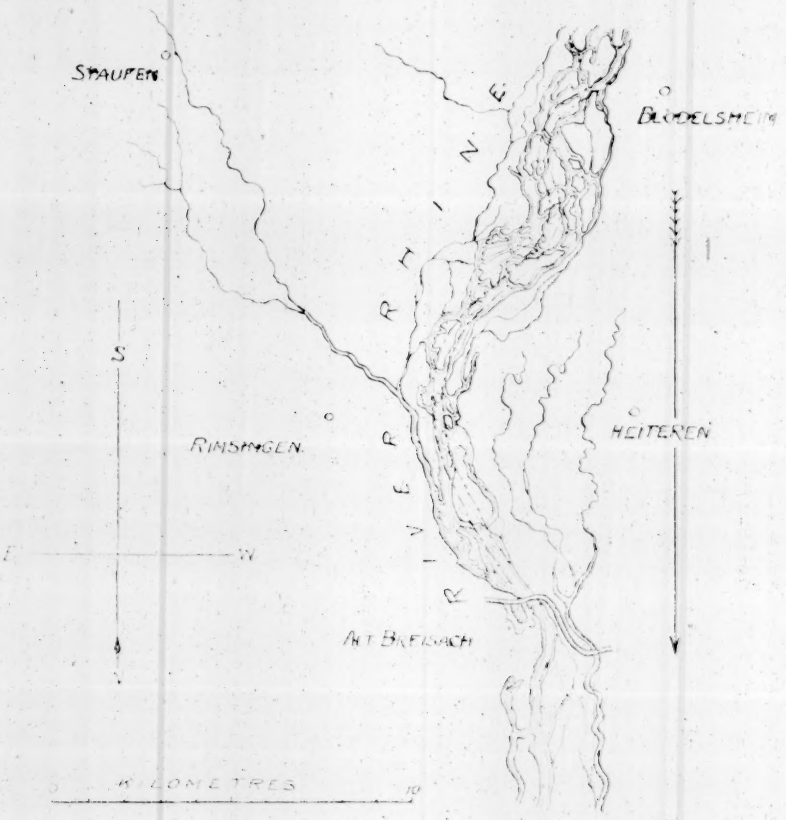


FIG. 2. Deviation of a river towards a tributary; on the opposite side, streams formerly continuous with the network above.

VI.—Notes on the Geology of Basutoland.

By the Rev. S. S. Dornan.

(*Concluded from the February Number, page 63.*)

Of all the animals of the Stormberg Beds the Theriodonts are the most interesting, as they bear strong resemblances to mammals. Dr. Broom, of Stellenbosch, says they have practically solved the problem of the origin of mammals. Of these Theriodonts only two are said to have come from Basutoland, both of small size, viz. *Galesaurus* and *Tritylodon*. They are only known from their skulls. I have not

been able to discover whether they came from Molteno Red Beds or Cave Sandstone, but I imagine most likely from the first. *Tritylodon* has a small and decidedly mammalian-like skull, and is said to have been found at Thaba Tsuen, a mountain 16 miles south-west of Morija. It was brought to England by Dr. Exton, Curator of the Bloemfontein Museum, and described by Sir Richard Owen at a meeting of the Geological Society in 1884.[1] Dr. Broom, who has recently discussed the affinities of the skull, inclines to the view that it is a mammal.

(1). The volcanic beds are by far the most typical rock features of the country. They are confined to the high ranges of the Malutis, which form the backbone of the country. The Malutis consist of at least two and in most places three or four parallel ranges of mountains. The average height is 7,500 feet. The necks seem to lie in three or four lines, roughly corresponding to the ranges which now form the Malutis and Drakensberg. A study of the present river system of the country bears out this view, as the Orange River and the Caledon run in approximately parallel courses, and this specially applies to the tributaries on the right or northern bank of the Orange River. The first range of necks builds up the great mountains known as Bitsolebe, Machache, Thaba Phutsoa, and Matelile. The next range, 25 miles to the south-west, contains the great necks known as Dikolobeng, Mokhele, and Thaba di Noha. To the north and east of this there is another composed of still higher summits, amongst them not only the highest in Basutoland but in the whole of South Africa, namely, Mount Hamilton 11,500 feet, Lateba's Nek 10,842 feet, Motar 10,400 feet, and Bukotabelo 10,000 feet. The last range composes the mighty wall known as the Drakensberg, and includes the Mont aux Sources 11,170 feet, Champagne Castle 10,357 feet, Giant's Castle 9,657 feet, and many others. Besides these well-defined ranges, there are many other smaller ones scattered around and between them. It must be remembered that many of these heights are not absolutely reliable, as no proper surveys have been made.

The volcanic beds consist of vast piles of lavas and ashes. Siliceous tuffs are not plentiful. I have seen two or three small examples. The thickness ranges from 500 to 1,000 feet. The lavas are amygdaloid and doleritic near the base of the group, often columnar near their junction with the Cave Sandstone. Higher up in the group truly vesicular and scoriaceous varieties occur, interbedded with thick deposits of ash purple in colour. The greater part of the lavas is amygdaloid, with the cavities filled with quartz or calcite. Weathered surfaces on the lavas indicated by bands of red clay are entirely absent. The thickness of the individual beds varies very much, from a few inches up to 20 feet or more. Many of the flows are full of pipe-like vesicles, usually from 4 to 6 inches in length and from $\frac{1}{8}$ to $\frac{5}{8}$ of an inch in diameter, filled with calcite. These vesicles are not quite perpendicular to the plane of the bed, but inclined towards the vent from which the flow took place. They are more or less spherical and often branch at the top. Occasionally the calcite is completely weathered out, leaving the pipes open, so that a bed of lava at its surface and along its fractured edges looks not unlike a honey-

[1] See Quart. Journ. Geol. Soc., vol. xl (1884), pp. 146–151, pl. vi.

comb. Most of the lavas are basalts, but andesites occur, not only intermingled with the others, but composing entire hills themselves, as at the magistracy of Mayeni in South Basutoland. Agglomerate necks are of frequent occurrence, filling up the great vents, and also in small isolated necks. Most of the indications presented by the lavas of Basutoland point to their deposition in water. This, however, is difficult to reconcile with the fact that in two instances where the junction of the lavas and the Cave Sandstone is exposed, the former rest on the eroded surface of the latter. The upper members of the Cave Sandstone seem also to have been removed by denudation prior to the deposition of the volcanic beds. In the lower flows of the group thin intercalated beds of sandstone occur, pointing to an interruption of volcanic activity, the thickest being 3½ feet. A short description of two of these volcanic peaks, Thaba 'Telle and Thaba di Noha, will serve as examples of all the rest.

Thaba 'Telle is a mountain about 7,800 feet high, rising abruptly from a platform of Cave Sandstone. Its lower slopes consist of doleritic lavas, alternating with vesicular varieties and beds of purple ash, and at the top of agglomerate, evidently the remains of the old throat. The lavas are just under 2,000 feet in thickness. The mountain is a kind of three-sided cone, with steep, often precipitous sides, and was once much more extensive than now. The summit is a plug of naked agglomerate standing up to a height of fully 100 feet, exceedingly steep and in some places overhanging. It can only be climbed at one point where there is a crack left by the weathering away of a doleritic dyke, and then only with considerable difficulty and risk. The top is convex and grass-grown about 30 square yards in area. The view from the summit is magnificent, as several prominent volcanic peaks can be seen in the distance. This plug is the resort of multitudes of vultures that make their homes in the cracks and fissures of the rock. The lavas of Thaba 'Telle are full of steam holes, more especially in the upper beds, and about the middle of the beds are two thick deposits of ash separated by a thin bed of amygdaloid lava. This alternation of beds can be made out at some distance, as the ash is light purple in colour, and the lava a deep shining black. The same phenomenon occurs elsewhere. Near the base of the mountain is a large intrusive sheet surrounding what was once a subsidiary cone, but what is now nothing more than a mere plug of doleritic lava and agglomerate. This sheet is of much later date than the surrounding lavas which it penetrates and overlies. From it spring two immense dykes that traverse the country for miles in practically straight lines.

Thaba di Noha. This mountain is about 50 miles, as the crow flies, from Thaba 'Telle, and rises immediately behind the magistracy of Mohale's Hoek. It is the extreme western point of the great Mokhele range. It is about 7,500 feet high. The bridle-path from Mohale's Hoek to Moyeni leads over the plateau from which the mountain rises, between the plug and what is presumably the old crater wall. It is a typical volcanic vent, and one can trace the outflow of the lavas on the north side of the hill. At one point where a stream has cut through, they are steeply inclined, glassy, and weather into coarse splintery

fragments about 10 or 12 inches in length, not unlike spear-heads. At another place, a little higher up, they are ropy and scoriaceous. The whole crest of the mountain consists of doleritic amygdaloid lavas, interbedded with vesicular varieties and very thick beds of ash. The vesicles in the lavas are generally filled with calcite. An exposure of the junction of the lavas and the Cave Sandstone occurs in the bridle-path upon this mountain, and indicates that erosion of the Cave Sandstone had taken place before the deposition of the Volcanic Beds, but the evidence is not decisive. The erosion may be due to a subsequent and different cause. This does not apply to an exposure near Sefikeng, which plainly indicates erosion. Many of the highest summits, such as Mount Hamilton, Mont aux Sources, Bitsolebe, etc., contain a vertical thickness of over 4,000 feet of lavas and ashes. These mountains, with the exception of the last, are situated in very difficult and broken country, far from centres of population, and as I have not visited them personally I am unable to describe them in detail.

Connected with the lava beds are a great series of intrusive dykes and sheets. They cover a considerable extent of country, and traverse all the Stormberg Series. They are subsequent to the Volcanic Beds, and so far as I can make out are of the same age as the Karroo dolerites of the Cape Colony and of similar composition. Amongst the many scores of them that I have examined I cannot say that I have ever observed any decided characteristics of a lava-flow. Doleritic lava can be generally separated from doleritic intrusions, not only by its appearance but also by its mode of occurrence. A doleritic sheet weathers red, which doleritic lavas never do, at least so far as I have seen them. Some of the dykes are only a few inches wide, and upwards of 50 feet long, sending out side-branches. By far the larger number are from 10 to 20 feet in thickness and several miles in length. They traverse the country in all directions like great roads running up and down the hills, and usually terminating in a large sheet. There are many examples of this kind, as for example at the mountain Thaba Tsuen. It crops out in the valley to the west of the cone; sends two parallel dykes up the mountain at very steep angles, and separated by rather less than a mile. These dykes traverse the lower lava beds, reappear on top as two shallow parallel trenches, and then pass into an immense sheet nine or ten miles in length by four in width, which attains in places a thickness of 400 feet. Near Mohale's Hoek two remarkable examples of intrusive dykes are to be seen. The first runs across the country with perpendicular sides like a huge wall for about seven miles, traversing the lavas of the Mokhele range. At one point where a stream has cut through the side of the dyke the dolerite assumes a columnar structure closely resembling basalt. The Molteno sandstones through which it has broken are much altered. The other dyke is a conspicuous feature of the landscape, and runs in an east and west direction for upwards of 15 miles from the volcano Mokhele to Raboroko. It is perfectly straight, 30 feet thick, and about the same in height, but more must be hidden by superficial accumulations. It stands up in the form of a huge causeway, and is much weathered at the top and sides, the nodules ranging in size from

a marble up to masses two feet or more in diameter. The edges of the rent into which the molten dolerite has been injected are as clean-cut and straight as if laid out artificially. Small displacements of the neighbouring strata are characteristic features of these dykes. Occasional enclosures of sandstone occur in dykes, but they rarely exceed three feet in thickness. From observations made at widely separated places, I am convinced that these dykes and sheets were intruded into the lavas long after volcanic action had ceased, at least from the main centres of eruption, but before the earth-movements to which the country largely owes its present configuration had begun.

Recent and superficial deposits cover the low grounds, and consist of stratified clays, sands, and gravels. The pebbles of the gravels consist of fragments from all the Stormberg rocks. In many places these deposits are more than 30 feet thick. The rivers in the course of ages have cut their way through them, and, as they are loose and easily removed, the amount swept away by every storm is considerable. Large masses fall from the banks during the rains, with the result that a small stream becomes in a short time a huge gaping donga. These dongas everywhere intersect the country, and are a positive danger, especially during the rainy season. The destruction of the wood and bush of the country, together with the increase of cattle that eat off the grass, has powerfully assisted the formation of these dongas. They not only reduce the area of arable land, but also drain off the water and disfigure the country. If nothing be done to check their formation they will render the water problem a very serious one at no distant date. When the first missionaries came to Basutoland about 75 years ago multitudes of these dongas did not exist. A deep donga near Morija was forty years ago a small stream that one could step across; now it is a trench 15 feet deep and more than 20 feet wide. It is a pity that the Basuto cannot be induced to plant trees more extensively. They would at least do something towards checking denudation, besides being useful as fuel in a country where such a commodity is exceedingly scarce. The Government is trying to induce the natives to plant by the gift of trees, and they are slowly waking up to the necessity of it.

The most interesting of the superficial deposits are the sand dunes on Thaba Bosiu mountain. They occupy the south-eastern portion of the plateau, and travel east or west according to the direction and strength of prevailing winds. These sand dunes are formed of disintegrated Cave Sandstone, the grains being chiefly quartz and felspar. They cover many acres in extent. Thaba Bosiu is the necropolis of the Basuto chiefs, and every paramount chief, besides many sons and brothers of the ruling chiefs, have been buried there. The sand-hills have partially covered up the graves and appear to be slowly travelling towards the east, as some of the graves formerly hidden are now exposed. They never approach close to the precipitous edge of the plateau, as apparently the updraught of the wind in rushing round and over the plateau prevents the sand from falling over the precipice. They are also beautifully ripple-marked by the wind, and some of them are quite 20 feet in height. Not far from Morija there is the basin of an old lake, just as there are many such prehistoric lake basins over

the surface of the country, in which there have been found Palæolithic flint implements. Some of the floors upon which these flint implements have been found are 60 and 70 feet above the present levels of the rivers. The lake basin referred to above is now quite filled up, and is only represented by a marsh, as the river which formerly drained it has cut a deep channel for itself, removing the surplus waters. It is about six square miles in area, and the beds of sand and gravel filling it up are well exposed in the bed of the stream. They are over 30 feet thick. This lake existed from a remote period until quite lately. It ought to be a likely place for fossils, but none have been found. A few fossils have been discovered in other gravels in various parts of the country, belonging, so far as is known, to species still living, but some of which no longer inhabit the country. The skull of a hippopotamus was obtained many years ago from the bank of the Caledon River near the station of Hermon, and I am informed the remainder of the skeleton is still there, as the people objected to its removal. Tusks of the wart-hog, together with scattered bones of other animals, have also been found. The wart-hog is quite extinct in Basutoland, and has been for a considerable time. It is probable from the age of some of the oldest of these deposits that recently extinct animals might also be found.

So far as can be seen it is probable that the drainage of the country, from the time of its elevation at the close of the Stormberg Period, has followed pretty much its present lines. A glance at the sectional map of the country, from Morija to the Natal border east and west, compiled by the Rev. R. H. Dyke from notes made by him in 1883 and 1884, will show this.[1] The Caledon River flows in a shallow syncline trending east-north-east, and there is no trace of any change in the direction in recent times. The same may be said of the Orange River and its tributaries, which have cut their way through the plateaux and formed steep-sided valleys nearly 2,000 feet deep, and in some places much deeper than that. On the Maletsunyane River, a tributary of the Orange, there is a magnificent waterfall 632 feet high, formed by the river cutting back its bed. Ages of denudation have hollowed out deep troughs, in the bottom of which the rivers now run with a general southerly direction, carving the volcanic beds into three and in some places four parallel ranges. This has been powerfully assisted by earth-movements subsequent to the cessation of volcanic activity. There have been two distinct thrusts. First one from east to west, giving the Stormberg Beds their general easterly dip, next one approximately at right angles to this. The first produced the series of synclinal folds, which the country presents on traversing it from the Caledon River to the Drakensberg; the second gave a gentle rise to the country from south to north, assisting the rivers to deepen their beds.

A good example of river erosion on a small scale is to be seen near the station of Hermon in the west of the country, where a small tributary of the Caledon has cut its way through a doleritic intrusive

[1] Published in "Papers read at the joint meeting of the British and South African Associations for the Advancement of Science, 1905," vol. ii, p. 129.

sheet 200 feet thick, and there is no indication that the stream ever followed any other course. The best examples of river erosion are to be seen in the gorges of the Malutis, but I have never had the good fortune to visit them. The scenery of these parts of the country is remarkably grand in places, and well merits the title bestowed upon it of the Switzerland of South Africa.

REVIEWS.

I.—Geology of the Panama Canal.

To the journal entitled "Economic Geology, with which is incorporated the American Geologist" (vol. ii, Oct.-Nov., 1907), Mr. Ernest Howe contributes an essay on "Isthmian Geology and the Panama Canal." He observes that the widespread decomposition to which all the rocks have been subjected, and the thick mantle of soil and vegetation, offer great obstacles to the study of the geology of the region; but he was fortunately able to examine numerous artificial excavations and records of borings. The oldest rocks along the Canal route, andesitic tuffs and breccias with associated flows, occur in the central and southern portions. Resting upon these on the Atlantic or northern side of the Isthmus are fossiliferous conglomerates, sandstones, and shales which dip at low angles toward the Caribbean Sea, so that in passing from the interior to Colon successively younger beds are encountered, the oldest carrying an Eocene fauna, and the youngest late Oligocene, according to Mr. W. H. Dall. On the Pacific or southern slope the Eocene strata extend for some distance and disappear beneath beds of acid pyroclastic rocks, which in turn are to be traced almost continuously to the shore near the Pacific end of the Canal. Ancon Hill, which dominates the city of Panama, consists of massive rhyolite porphyry, that is believed to mark the site of a volcanic vent, from which the acid tuffs and breccias of the neighbourhood were erupted. Tuffs of nearly the same composition are found on the Atlantic side in the vicinity of San Pablo and Tabernilla, and similar rocks occur at Gatun, interbedded with fossiliferous Oligocene sediments. The deposits on the Pacific side are believed to be contemporaneous with these. Cutting all these earlier Tertiary rocks are irregular dykes and stock-like masses of pyroxene-andesite and basalt, which are considered to be of Miocene age.

The general structure of the Canal route is therefore a broad flat anticline, having a nearly east-west axis; but there are many small folds and faults, and evidences of local unconformity, which show that differential movements of the land took place at intervals from the Eocene period onward.

The author deals with the origin of the present topographic features that have resulted from the erosion and deposition that attended three well-marked epeirogenic movements; and in connection with them a notable feature, discovered and located entirely by means of borings, is a buried Pleistocene valley, that has afforded not only great scientific interest, but also the most important problem with which the engineers of the Canal have had to deal.

II.—Geological Survey, Western Australia. Bulletin Nos. 24, 25, 1906; Nos. 26, 30, 1907. A. Gibb Maitland, F.G.S., Government Geologist. 8vo; with maps, plates, and figures in the text. Perth, W. A.

Bulletin No. 24 contains an account of the Laverton, Burtville, and Erlistoun auriferous belt of the Mount Margaret Goldfield, by Charles G. Gibson, Assistant Geologist. The report is one of the special series dealing with the mineral resources of the State, and it includes a brief summary of the work of other observers in the same area.

The boundaries of the Mount Margaret Goldfield embrace an area of 42,252 square miles. The formations met with constitute a complex of crystalline rocks, to which the general terms 'greenstone' and 'granite' are provisionally applied. The greenstones are essentially hornblende rocks, ranging through typical diorites to a fine-grained rock, consisting almost entirely of hornblende. The granitic rocks are in some places found to be intrusive in the greenstones in the shape of dykes and masses; in others their relations to the greenstones cannot be determined with certainty owing to the covering of recent deposits. They vary in character from a dark hornblende granite or quartz-diorite, to a light coloured quartz-porphyry. The group of rocks here called greenstones is the most important from the economic point of view, as it generally contains the auriferous ore bodies.

This report is illustrated with geological and mining maps and illustrations of geological phenomena.

Bulletin No. 25 is a report upon the "Prospects of obtaining Artesian Water in the Kimberley District," by R. Logan Jack, who was specially appointed to undertake the work. After referring to previous surveys made by E. T. Hardman, H. P. Woodward, and A. Gibb Maitland, which paved the way for later investigators, the writer takes the geological formations met with in the district as follows:—

Carboniferous Sandstone.
Carboniferous (?) Limestone.
Devonian Sandstone, Grit, and Limestone.
Metamorphic Rocks—Slates, Schists, Gneisses, etc. (Silurian, Cambro-Silurian, or Cambrian).
Granite.
Basalt.

These are briefly described from the author's observations while drawing special attention to the pioneer work of Hardman in this field. In summing up his results Dr. Jack refers to the nine distinct areas that he examined and in which he anticipates more or less success in the search for artesian water. He concludes that the latter is destined to play an important part in the pastoral industry of the Kimberley District. An appendix to this report gives an itinerary and notes on water. There is also a coloured geological map (scale 12 miles to 1 inch) with explanatory notes upon its face, and a full index.

Bulletin No. 26 includes a series of reports which were too short to be separately issued. They relate to the mineral and other resources

of the country. The first, by Mr. Gibb Maitland, deals with the occurrence of artesian water; the second, by Mr. H. P. Woodward, refers to the same subject in connection with the Gascoyne area. The phosphatic deposits near Dandaraga are described by Mr. W. D. Campbell. A small meteorite (siderite) from the Nuleri district is described by Mr. E. S. Simpson, whose account of it is well illustrated from photographs. "The geology of Princess Royal Harbour, with reference to the occurrence of oil," and "Recent advances in the knowledge of the geology of Western Australia" form the subjects of two papers by Mr. Gibb Maitland. The second of these was Mr. Maitland's presidential address before the Section of Geology of the Australian Association for the Advancement of Science in 1907. This is of much interest as a comprehensive summary of the geology of the country. The writer devotes particular attention to the older rocks of the State, consisting of crystalline, schistose, and metamorphic rocks, considered to be possibly of Archæan age, though the term pre-Cambrian is used in preference to designate them. These rocks occupy about two-thirds of the total superficial area of the State, which comes to about 975,920 square miles. They consist of rocks of various types, many of them in a crystalline condition, forming coarse crystalline schists and gneiss, differing but little from granite and rocks of similar origin, as well as basic rocks which have been more or less crushed, foliated, and completely converted into greenstone schists. The sedimentary rocks are representative of the Cambrian, Devonian, Carboniferous, Jurassic, and Tertiary periods, and are all recognizable by their fossil contents. Finally, volcanic rocks occupied an important place in the geological history of Western Australia. They are to be found in the shape of lava-flows, ash beds, breccias, dykes, etc. Igneous activity took place, it appears, in three distinct periods, viz., in pre-Cambrian time prior to the deposition of beds holding an Olenellus fauna; early in Devonian time, but ceasing before the Carboniferous; after the deposition of the Jurassic beds, and finally in rocks believed to be of Tertiary age.

Two other papers are included in this report, viz., "Notes upon the geological map of the Greenough River District," by W. D. Campbell, and "Prevention of external corrosion of Goldfields water supply Pipes," by E. S. Simpson.

Bulletin No. 30 contains a report by E. S. Simpson and Charles G. Gibson on "The Distribution and Occurrence of the Baser Metals." In a prefatory note Mr. Harry P. Woodward explains the object of this bulletin to be for the purpose of aiding prospectors and persons interested in the search for metals other than gold. The metals dealt with are copper, tin, lead, zinc, antimony, bismuth, iron, nickel, cobalt, manganese, aluminium, tantalum, tungsten, and molybdenum. Particulars relating to the mining, yield, and value of these metals are set down in the report, to which a full index is appended.

A. H. F.

III.—Geology of India.

General Report of the Geological Survey of India for 1906, by T. H. Holland, F.R.S., F.G.S., Director. The Mineral Production of India during 1905, by T. D. Latouche, B.A., F.G.S. The Geology of the State of Panna, principally with reference to the Diamond-bearing Deposits, by E. Vredenburg, A.R.C.S., F.G.S.; also numerous papers on Indian Geology by the same author. A Preliminary Survey of certain Glaciers in the North-West Himálaya, by Officers of the Geological Survey of India.—All the above extracted from the "Records."

PARTLY in continuation of a review of the Geology of India which appeared in the Geological Magazine for July, 1907, we are now able to offer a few additional remarks on the progress of this far-reaching Survey. When we reflect that the area under consideration, though nominally India, extends from the crest of the Karakoram in Central Asia to the southernmost point of the Nicobar Islands, and from the confines of Persia on the west to those of Chinese Yunnan on the east, it must be admitted that this is a truly Imperial Survey, and that the variety of formations must afford a wide scope for official enterprise.

There are of necessity so many and such diverse subjects dealt with in this Report and the accompanying papers that it seems advisable, for the purposes of review, to alter somewhat the arrangement adopted by the Director, and to place the several subjects more or less on a chronological basis so far as this is practicable.

Existing phenomena.—There are two subjects dealt with in this category.

(1) "River action." Mr. Holland drew the attention of the Board of Scientific Advice to the unsatisfactory nature of our information regarding the data available as to the amounts of silt and dissolved salts carried by the large Indian rivers to the sea, and, on the recommendation of the Board, Government sanctioned the institution of systematic investigations. These, it is thought, will materially assist in the estimation of the amount of denudation going on, and be of much interest to geologists. Steps have been taken, notably in the case of the Indus, to determine the amounts systematically. This is for many reasons an excellent move, but the problems of denudation, which it is hoped to solve, must of necessity be complicated where the rivers drain such a rare and exceptional area as that occupied by the Himálayan system. The rivers of Central India might yield results of a more normal character.

(2) "Himálayan glaciers." The importance of determining the secular movements of these glaciers has been recognized, and a preliminary survey of the principal ones in the Kashmir, Lahaul, and Kumaon region instituted. Of all these glaciers plane-table sketches were made showing the exact positions of the 'ice-caves' with reference to points fixed on rocks in the valleys, as well as with reference to prominent and unmistakable peaks in the vicinity. In

Kashmir, so called, six glaciers belonging to Hunza, Nagir, and Bagrot have been visited, and sketch-maps, supplemented by photographs, of their 'snouts' have been prepared with a view to determine the direction and amount of their secular movements. The glaciers fall into two classes, viz., those which lie in troughs parallel to the mountain ranges, and those which flow at right angles to the ranges; the former longitudinal, the latter transverse glaciers. The Kashmir section of the Survey is illustrated by numerous photographs taken by Hayden and reproduced (collotype) by Bemrose of Derby. These pictures, regarded simply from an artistic point of view, are exquisite landscapes, in addition to their utility from a geological point of view. The photograph of the terminal ice-cave of the famous Hispar glacier, in conjunction with the explanatory sketch-map, affords a most instructive picture, whilst that of the Hassanabad glacier (already reproduced in *Nature*, January 2nd, 1908, p. 201) presents features of quite a different character. Moreover, this latter glacier has been increasing in length of late years, contrary to the general practice of Himálayan glaciers. The work on the glaciers of Lahaul and Kumaon is equally interesting and artistic, and as a result of the entire survey posterity will be able to form an accurate estimate of the movement of all these glaciers in future. How poor Marshall Hall would have rejoiced at this!

As might well be expected, the glaciers of the Hunza Valley and the Karakoram range generally descend to lower levels than those in the Lahaul and Kumaon regions. In the former the snouts of the glaciers proceed down to levels of 7,000 or 8,000 feet, whilst in the latter they melt before descending below about 11,000 feet. The second point most prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines at lower levels in the valleys. If we remember rightly, this seems to corroborate the experience of Hooker in Nepal during the fifties of the last century. Mr. Holland points out, however, that these results do not necessarily mean that the glaciers are now in retreat, and he gives two cases where a recent advance has been made. The evidence with regard to the erosive action of ice is said not to be conclusive.

Tertiary.—In this connection Mr. Vredenburg, who has recently been appointed Palæontologist, appears to have done good work, especially in Belúchistán. The Director remarks that Mr. Vredenburg has paid especial attention to the distribution of the foraminiferal genera *Orthophragmina* and *Lepidocyclina*, in view of the doubts that have been expressed as to their constant separation in European Tertiary strata. So far no instance has been noted in India where these two genera are in association with each other. *Lepidocyclina* has never been found below the Nari (Oligocene), whilst *Orthophragmina* has never been found above the lower zones of the Upper Khirthar (Eocene). Thus these two genera retain their distinctive stratigraphical value.

The general result of Mr. Vredenburg's work tends to emphasize the importance of the breaks in the Tertiary formations. In the Belúchistán area, where the beds are more disturbed, the unconformities are obvious from the stratigraphical evidence; whilst in Sind, where

the only serious orogenic movements occurred in late Tertiary times, there is a general physical parallelism amongst the lower Tertiary strata, but the interruptions in deposition are, according to Mr. Vredenburg, none the less pronounced when the palæontological evidence is sifted. Thus there is found to be a conspicuous break, both stratigraphical and faunistic, throughout the regions under description, between beds of Eocene and those of Oligocene age, which latter pass upwards by gradation into the equivalents of the Lower Miocene. A break again occurs before the establishment of the Manchar (Siwalik) strata.

At the base of the Tertiary system itself there occurs an important break, separating it from the *Cardita Beaumonti*-beds of Cretaceous age, which are placed by Mr. Vredenburg as low as the Maestrichtian. It is concluded, therefore, that the uppermost Cretaceous beds of Western India are separated from the Tertiaries by a gap, occupied by the Thanetian and Montian stages in Europe.

Under the heading of "Tertiary" we must advert briefly to the geology of the Andaman Islands, which attracted the attention of Indian surveyors some years ago. According to a recent survey it would seem that beds of Tertiary age are largely represented in these islands. Mr. Tipper shows that beneath recent and sub-recent formations of no particular interest there are clays, foraminiferal limestones, sands, and shell-marls of Miocene age; also in North Andaman a large outcrop of coarse sands and conglomerates with *Nummulites atacica*, Leym., and *Assilina granulosa*, D'Arch., of Eocene age. In South Andaman the Eocene beds are represented by micaceous sandstones and shales with leaf impressions, etc. The underlying serpentines, gabbros, and diorites are probably of Upper Cretaceous age. A comparison with the rocks of the Aracan Yoma shows that the Andamans are a continuation of the same system.

Cretaceous.—As a further contribution to the probability of the Cretaceous age of the Deccan Trap, Mr. Vredenburg announces the recognition, amongst beds of Maestrichtian age in Beluchistán, of the characteristic Intertrappean fossil *Physa Prinsepii*, Sow. In Central India the examination of the Deccan Trap and Intertrappeans has continued, and some interesting facts with regard to the old soils and the fresh-water deposits have been noted. At one locality, where an Intertrappean bed is well developed, it was found to consist of 6–10 feet of cream-coloured marl and limestone, the upper layers of which were crowded with well-preserved specimens of *Physa*. It is of interest to note that the respective areas, where red clay bands and Intertrappean aqueous deposits are found, do not commingle, a fact which bears out the interpretation that the former represent old land surfaces and the latter areas more or less under water.

Triassic.—A special memoir on the Triassic fossils of the Central Himálayas appears in the *Palæontologia Indica*, and supplements the descriptions of older collections. There is a strong similarity between the Himálayan and the Alpine Muschelkalk. The upper beds are especially rich in Brachiopoda, whilst in the lower beds Cephalopoda predominate. Amongst the Cephalopoda described in the memoir twelve species are either closely related to or identical with those

previously known in the Alpine Muschelkalk, whilst three characteristic species of Brachiopoda are common to both areas. Of the Cephalopoda 148 species belonging to 41 genera and subgenera are now known in the Himálayan Muschelkalk. The Triassic faunas of the Himálayan regions approximate more closely to the Alpine province than to the "Arctic-Pacific."

Permo-Carboniferous.—Certain limestones lying to the eastward of Mandalay in Burma, which were formerly regarded as Silurian, have been shown by Mr. Latouche to contain specimens of *Fusulina* and corals, indicating the presence of Permo-Carboniferous beds, whose occurrence in various parts of the Shan plateau had been previously announced.

But the most interesting intelligence in connection with this horizon comes from Kashmir, where evidence has been obtained which seems likely to set the almost everlasting Gondwana question at rest. It appears that, after considerable doubts as to the correct interpretation of a somewhat debatable section, Mr. Hayden discovered *Gangamopteris* and other plant-remains in Godwin-Austen's typical section near Zewan, about 9 miles south-east of Srinagar. The rest of the story should be told in the Director's own words:—

"In this section the trap-flows are covered with apparent physical conformity by an oolitic limestone, which has been made crystalline and largely converted into novaculite. Above the limestones are beds of siliceous shales covered conformably by the *Gangamopteris*-bearing beds, which pass up through a perfectly conformable series, about 150 feet thick, to limestones containing *Protoretepora ampla*, Lonsd., near the Zewan series of *Productus*-limestones. The *Protoretepora*-beds are without doubt the equivalent of the *Fenestella*-shales of Spiti, and are therefore of Upper Carboniferous age, giving the upper limit for the *Gangamopteris*-bearing beds. We have thus at last obtained positive proof of the existence of this characteristic Lower Gondwana plant in rocks that cannot be younger than the English Coal-measures, and are possibly even Middle Carboniferous in age. As *Gangamopteris* occurs in the lowermost beds of our Gondwana system the long-disputed contention of the Geological Survey of India as to the Palæozoic age of the Lower Gondwanas is finally settled by positive evidence; and, although other workers have been so near discovering the one link wanting, the honour of completing the chain of evidence belongs to Mr. Hayden."

Devonian.—Two Devonian horizons have been proved to exist in Burma on palæontological evidence, but their stratigraphical relations to beds believed to be Permo-Carboniferous are not as yet known. The most important fauna includes an abundance of Corals, Bryozoa, and Brachiopoda associated with a very small number of Crinoids, Molluscs, and Trilobites. This fauna is thought to resemble that of the Eifel: *Calceola sandalina* is especially abundant. It may be worth while mentioning that the small collection of Devonian fossils obtained by McMahon in Chitral appears to resemble this one in the relative abundance of Brachiopoda and Corals. Another Devonian collection from Burma, instead of resembling a European fauna of this age, is said to include many species related to or identical with the Hamilton Series in North America.

Pre-Cambrian.—The great unfossiliferous Vindhyan system, so important a feature in Central India, has attracted some attention of late from the Indian Survey, and Mr. Vredenburg has even suggested a new classification, though perhaps only provisional. Into these details we need not enter, but there is one subject in connection with the Vindhyans to which some allusion might be made, viz., the Diamantiferous Conglomerate occurring in the Rewa division of the Upper Vindhyans near Panna in Bundelkhand. The diamond industry in India at present is only a small affair, and therefore the subject is unimportant from an economic point of view. Yet the occurrence of the diamonds otherwise than in an ordinary alluvial gravel is interesting, as possibly tending to throw some light on the origin of the gem. For this purpose it will be necessary to study the geological conditions under which the Diamantiferous Conglomerate occurs. The Archæan base of the country is held by a Granite, which, even if newer than the Aravalli system, is the oldest rock in Bundelkhand. This Granite, where exposed, is seen to be seamed by quartz-reefs, and these again are cut, approximately at right angles, by linear dykes of basic igneous rock. These dykes appear to represent a period of volcanic activity contemporaneous with the Bijáwar system, an unfossiliferous sedimentary formation which, in places, intervenes between the Granite and the Lower Vindhyans. In Southern India similar dykes of the same age occur abundantly in the neighbourhood of diamond-bearing deposits like those of Bundelkhand, "an association which suggests some possible genetic relation." The Bijáwars were extensively disturbed before the deposition of the Vindhyans, which partly rest upon them quite unconformably. Their denudation supplied the Vindhyans with a vast amount of material, the bright-red pebbles derived from the bedded jaspers and fault-breccias being particularly conspicuous in some of the Vindhyan conglomerates, which likewise contain a peculiar jaspery sandstone of a greenish colour derived from the denudation of a portion of the Lower Vindhyans.

Having discussed the probable origin of the material, Mr. Vredenburg next proceeds to define the position and mode of occurrence of the diamond-bearing deposits. There are two thin conglomerates (seldom exceeding two feet) in each case capping sandstones and underlying shales, of which the lower one is the best known and the most important. The pebbles of the Lower Rewa conglomerate are derived partly from the quartz-reefs of the Bundelkhand Granite, partly from the Bijáwars and Lower Vindhyans. Fragments derived from these two sedimentary formations are absent from the Upper Rewa conglomerate, which only contains pebbles of vein-quartz. These quartz pebbles derived from the granite area are therefore the essential associates of the diamonds, "and the original home of the gem must be one of the rocks of the granitic region, either the Granite itself, or its quartz reefs, or the basic dykes." Further on, however, Mr. Vredenburg, commenting on the presumed absence of diamond workings in the Bijáwar conglomerates, both in Central and Southern India, suggests that the diamonds are not older than the Bijáwar, "which supposition, coupled with their evident derivation from the crystalline area, points

to the basic dykes of Bijáwar age as their possible *nidus*." So far as we know at present, the almost invariable association of the diamond in South Africa with ultra-basic rocks inclines us to believe that its birthplace occurs in a magma of this character. Hence the basic dykes so often quoted by Mr. Vredenburg may really be the original home of the gem, though the basic material itself could never endure the attrition inevitable in the formation of a conglomerate.

To use a popular expression, these Panna diamonds are "small potatoes and few in a hill," whilst their derivative character helps us very little towards a recognition of the source whence they originally proceeded. The majority of the crystals are said to be small, yet of a good water and lustre, and very seldom clouded or flawed. Their commonest defect consists in the presence of 'spots,' which are black, opaque inclusions of jagged outline. Owing to this defect a large number of the stones are unfit for the European market.

(*To be concluded in our next number.*)

IV.—Système Silurien du Centre de la Bohême, par Joachim Barrande. 1e partie: Recherches Paléontologiques. Continuation éditée par le Musée Bohême. Vol. iv: Gastéropodes, par le Doct. Jaroslav Perner. Tome i, 1903; Tome ii, 1907. Traduit par A. S. Oudin.

THIS work supplies a need that has been long felt by palæontologists studying the Gasteropoda of the Palæozoic rocks. As is well known, Barrande succeeded not only in accumulating an immense amount of material connected with the ancient fauna of Bohemia, but he also wrote a considerable number of volumes thereon. He, however, died before accomplishing the part on the Gasteropoda, and in his will desired Professor W. Waagen to continue it. Illness and subsequent death prevented this. Therefore, in April, 1900, the Barrande Commission requested Dr. Perner to undertake the work, and all the materials collected by the eminent French refugee were placed in his hands.

After a careful study of these large quartos, with due consideration for the difficulties involved, we must congratulate the Commission on the result of their choice. Dr. Perner shows not only extensive knowledge of the Gasteropoda of his own country but also of other countries, and he brings to bear on the subject a great breadth of observation, as well as a faculty for minuteness of detail. The translation into fluent French renders the work easy of comprehension by foreigners.

In the prefaces to the two parts Perner describes the difficulties he has had to contend with, the mode he has thought best to meet them, as well as the scope of the work. The material consisted of specimens, notes, and sketches accumulated between 1847 and 1883—the year of Barrande's death—and also of some 247 lithographed plates. These plates contain a superabundance of figures, not merely of different families and genera of Gasteropoda (often mixed up unsystematically), but they even include various organisms belonging to other branches

of the animal kingdom which he had mistaken for Gasteropoda. Barrande drew the figures as the material came to hand during successive years, a practice that involved much repetition. On the one hand he laid stress upon minute distinctions of little moment, while on the other hand important features of detail and ornament to which much value is now attached were sometimes overlooked. To compensate for this latter deficiency Perner has introduced numerous admirably executed drawings into the text. The indiscriminate mixture of figures has been much more difficult to cope with satisfactorily. Perner has considered it best to give the descriptions in zoological order, and has in the main followed the classification of Pilsbry in the Text-book of Palæontology by K. A. von Zittel, translated by C. R. Eastman, vol. i, 1900.

Though tome i contains the descriptions of the families Patellidæ, Carpenter, and Bellerophontidæ, M'Coy, only, the plates of necessity contain in addition the figures of species belonging to many other families. To render these plates comprehensible before their detailed description can be published more than usually full explanations and notes are given. Tome ii also comprises figures of species which cannot be described before the publication of tome iii. Though Perner has used Barrande's plates, he has not been able to adopt his explanations and descriptions, as the real structure of the fossils and their phylogeny were then imperfectly known. He has been obliged to change many both generic and specific names, while adhering as far as possible to Barrande's nomenclature. This was all the more advisable as Barrande made out preparatory tables of genera and species which he named provisionally, and he also presented specimens to many European collections with his manuscript names attached.

In chapter I (tome i) Perner gives a chronological list of some forty-three works in which Bohemian species of Gasteropoda have been quoted. Amongst them is Bigsby's "Thesaurus Siluricus," 1868, where about 244 species are recorded whose names were transmitted by Barrande. Perner considers the Gasteropod fauna of the Bohemian basin more or less peculiar to that area, with the exception of there being an almost complete connection between the Gasteropoda of f2 (Devonian) and those of the calcareous deposits of Lower Devonian age in other countries. As Barrande's title "Système Silurien" is somewhat misleading, it may be well here to give a reminder that his étages, D, E, F, G, whose Gasteropoda are described in the volumes before us, include not only the Silurian formation as now understood but also the Ordovician and the Lower and Middle Devonian.

Perner divides the families into groups usually differentiated as genera and subgenera, the exact value of which cannot at present be accurately determined owing to the lack of sufficient material. He has, however, found it advisable to divide the family Bellerophontidæ, M'Coy, into two larger groups in the first instance, and then to subdivide these into genera, laying great stress on the presence or absence of a dorsal band, the first group, *Cyrtolitoidea*, being devoid of it, while the other, *Bucanioidea*, possesses it. This family and the Patellidæ, Carpenter, contain respectively 20 and 8 genera and subgenera (some of them new), comprising 153 species and varieties.

Tome ii describes many of the most interesting families, which are 13 in number and contain 105 genera, comprising 326 species and varieties. Thus we have a total in the two volumes of 133 genera and 479 species. In addition 147 other Gasteropoda are mentioned whose state of preservation does not admit of their being referred with certainty to any species or even genus.

Tome iii will contain the descriptions of five more families, comprising among others many species already figured in tome ii. The Capulidæ may be mentioned as an instance of this, 52 plates in tome ii being exclusively devoted to that family. The same volume will also furnish more particulars about the relationships between the Gasteropoda of Bohemia and those of other countries.

The families described in tome ii are the Pleurotomariidæ, Murchisoniidæ, Euomphalidæ, Trochoturbinidæ, Delphinulidæ, Neritopsidæ, Solariidæ, Scalaridæ, Littorinidæ, Loxonematidæ, Turritellidæ, Chemnitziidæ, Subulitidæ. Of these the Pleurotomariidæ ought by rights to have been described in tome i as the first family of the Rhipidoglossa, but as the plates destined for that part contained but few members of the family Perner thought it better to give the Bellerophontidæ the precedence.

There is considerable difference of opinion among palæontologists with regard to the respective limits of the families Pleurotomariidæ and Murchisoniidæ, Koken. Perner considers the form of the aperture the most important feature to be taken into account. Thus shells with more or less rounded aperture he places in the former family, and those with an oval aperture prolonged into a short canal in the latter. The possession of a nacreous inner layer, or of an elongated form, he regards merely of generic value. Both the *Murchisonia*, d'Arch. & de Vern., and *Pleurotomaria*, Sow., should strictly possess a slit in the outer lip, the filling up of which during growth gives rise to the formation of a band on all the whorls. Perner states that if *Pleurotomaria* be restricted to forms agreeing with the Mesozoic types, *P. anglica*, Sowerby, and *P. tuberculosa*, Defrance, it is not represented in the Palæozoic rocks of Bohemia. But he nevertheless considers that there exist several groups with certain features in common which may be placed with *Pleurotomaria* (taken in a more extended sense) in the family Pleurotomariidæ, and many of these have merely a sinus and not a slit in the outer lip. These groups he regards as constituting genera and subgenera; they number twenty-five, twelve of which are new, and most of the species are also new. Some of the old genera are extended so as to include more species, while others are restricted. Among the latter is *Lophospira*, of which the types given by Whitfield are *L. bicincta*, Hall, and *L. helicteres*, Whitfield. Ulrich considerably extended this genus, dividing it into numerous sections; Perner, however, restricts it to the *perangulata* section of Ulrich, of which *L. perangulata*, Hall, is the type. He includes some of Ulrich's species of *Lophospira* in *Worthenia*, de Kon., and he creates a new genus, *Coronilla*, for the *robusta* section of Ulrich, of which *P. robusta*, Lindstr., is the type. In the latter genus he gives four new species, all from the Upper Silurian (e2). In *Worthenia* he has also four new species from the

same horizon. *Lophospira* is represented by six species, all from the Ordovician (d4 and d5). Two of these are identified with the American *L. medialis*, Ulrich & Scofield, and *L. tropidophora*, Meek.

Only two species of the Pleurotomariidæ are mentioned as common to Britain. One of these from the Silurian (e2) is referred to *P. Lloydii*, Sow., which occurs also in Gothland, and is placed in the genus *Phanerotrema*, Fischer, by Perner. It shows a different structure above the band, but seems too badly preserved for accurate determination. The other is referred with a query to *P.* (*Bembexia*?) *Champernowni* (?), Whidborne, sp. It is merely an internal mould, so there can be still less certainty about its identification.

Perner also places in the family Pleurotomariidæ the genera *Stenoloron*, Œhlert, *Catanostoma*, Sandberger, and *Agnesia*, de Koninck, though he does not regard them as belonging to *Pleurotomaria*, s.l.

Stenoloron contains two new species, *S. pollens*, Barr. (f2), and *S. ambigena*, Barr. (e2), which are especially interesting for showing distinct traces of the very narrow grooved band, which had evidently possessed orifices along it at unequal distances represented by a row of elongated tubercles.

The Murchisoniidæ are divided by Perner into four genera, viz., *Pseudomurchisonia*, Koken, *Murchisonia*, d'Arch. & de Vern., s.l., *Sinuspira*, n.g., and *Ectomaria*, Koken. *Murchisonia*, s.l., he subdivides into eleven subgenera, of which five are new. The other three genera are distinguished from *Murchisonia*, s.str., by having a sinus and not a slit in the outer lip, and by not possessing a distinct band on all the whorls; indeed, the two last-named have no band, and *Pseudomurchisonia* (which is represented by one species) has a band on the later whorls only.

The new genus *Sinuspira* (which is also represented by only one species) is particularly interesting in that it apparently forms a link between *Murchisonia* and *Loxonema*; the lines of growth make a deep tongue-shaped sinus without any interruption in their course to form a band. Thus it comes near those species of *Loxonema* which have very sharply situated lines of growth, but it may be distinguished by the sinus being of greater depth, and the whorls being more convex and not adpressed at the suture.

Among the new subgenera *Leptorima* may be mentioned as remarkable for having a narrow deep band situated between two swellings high up on the whorl just below the upper suture. *Donaldiella*, Cossmann (*Goniospira*, Donald), is but doubtfully represented by two species, neither of which has so prominent a band as the type. *Ptychocaulus*, n.g., of which the type is the well-known *Murchisonia Verneuili*, Barr. (MS.), is distinguished by the peculiarity of a fold on the columella clearly shown by well-drawn sections of the shell. Another interesting feature in the Murchisoniidæ is pointed out by Perner, namely, the fact of the upper part of the spire being partitioned off in several instances.

The Murchisoniidæ range from the Ordovician (D–d5) up to the Middle Devonian (G–g1).

Previous authors such as Koken, Ulrich, and Scofield differ greatly in the genera they include in the family Euomphalidæ,

De Kon., and they also give many of them the rank of families. Perner considers it best to regard these latter as sub-families of the Euomphalidæ, and he divides these sub-families into genera. He states that true members of the Euomphalidæ, like the type *E. pentangulatus*, Sow., do not exist in Bohemia, and that the family takes quite a secondary place in the Gasteropod fauna. Only one new genus is described, comprising one species; it resembles *Euomphaloptervus*, but has certain distinctive features. The family occurs as early as the Ordovician (D–d 17), is most numerous in the Silurian (E–e 2), and is only represented by one species in the Devonian (F–f 2).

He adopts the family Trocho-Turbinidæ, Koken, for shells bearing a certain external resemblance to *Trochus* or *Turbo*. This group is very extensive in Bohemia, including no less than nineteen new genera and subgenera created by Perner. By far the greater number of species occur in the Silurian (E–e 1 and 2), but one, *Trochonema excavatum*, Barr., is found in the Ordovician (D–d 4), and others range up to the Devonian (F–f 2). For the genus of which *Euomphalus discors*, Sow., is the type he prefers retaining the name *Polytropis* given to it by De Koninck, as it has been so used for twenty years in spite of its preoccupation by Sandberger. In a note to plate 107 he states that he did not see Clarke & Ruedemann's "Guelph Fauna," where they suggest the name *Polemnita*, till this work was in the press.

Several small families follow such as the Delphinulidæ, Fischer, with one new subgenus; the Neritopsidæ, Fischer, containing only two genera, *Naticopsis*, M'Coy, with eight species named by Barrande in manuscript, and referred by him to *Natica*, and *Turbonitella*, De Kon., with five species, all also of Barrande in manuscript, except one which Perner considers identical with *T. Ussheri*, Whidborne.

The suborder *Ctenobranchia*, Schweigg, comprises two sections: (1) Pteroglossa, Troschel, containing the Solaridæ, with two new genera, and the Scalaridæ, Chenu, with eight genera, of which four are new; (2) Tænioglossa, Troschel, in which are grouped the Littorinidæ, Gray, Loxonematidæ, Koken, Turritellidæ, Gray, Chemnitziidæ, Koken, and the Subulitidæ, Lindström. Among these the families Littorinidæ and Chemnitziidæ each contains one new genus, while the Loxonematidæ has two new genera, namely, *Auriptygma* and *Katoptychia*. The former unites some of the characteristics of *Naticopsis*, *Holopea*, and *Macrochilina*. The latter greatly resembles the Triassic *Anoptychia*, Koken; each is represented by two species. *Auriptygma* is confined to the Silurian (E–e 2), and *Katoptychia* to the Devonian (F–f 2). Only three of the genera into which the family had been previously divided occur in Bohemia. Of these *Loxonema*, Phillips, comprises the greatest number of species, eleven of which Perner refers to *Loxonema*, s.str., and nineteen to a new subgenus which he calls *Stylonema*. None of the species have been previously described, and they range from the Silurian to the Devonian (E, F, and G). He confines *Loxonema*, s.str., to shells of the type of *L. sinuosum*, Sow., characterized by having oblique sutures and lines of growth strongly sinuated or almost subangular near the middle of the whorl. *Stylonema*, on the contrary, has the lines of growth in the main simply curved and seldom sigmoidal, with sutures more nearly horizontal.

Conditions of space render it impossible to notice more than a selection of the new and interesting forms treated. We trust, however, that enough has been written to show what a wide field has been ably traversed by Dr. Perner, and to awaken the desire to study his elaborate work *in extenso*.

JANE LONGSTAFF (DONALD).

V. — EARTHQUAKES: AN INTRODUCTION TO SEISMIC GEOLOGY. By WILLIAM HERBERT HOBBS, Professor of Geology, University of Michigan. New York, 1907.

THE work before us is one deserving of special attention from geologists. It cannot be denied that recent and very important advances made in the study of earthquakes have tended to throw the science of Seismology into the domain of the physicist and mathematician, rather than into that of the naturalist. The construction of delicate recording instruments, the unravelling of the complicated results of different kinds of wave-movement, and the discussion of the conclusions to be drawn from these as to the nature and disposition of the materials entering into the composition of our globe, make seismology (like the study of underground temperatures, terrestrial gravity, or terrestrial magnetism) an important branch of geo-physics. But while this aspect of the subject is not lost sight of, it should ever be remembered that the geologist has at least an equal claim with the physicist to be heard in the discussion of seismological problems. The records of the history of the earth's crust, as studied by the geologist, supply evidence concerning the nature and the effects of seismic action which cannot be neglected if we are to obtain the fullest possible amount of light upon the subject. It is true that the idea, formerly held by geologists, that there is a direct connexion between volcanic and earthquake phenomena, has been steadily losing ground; but, on the other hand, the intimate relations between earthquake movements and the geological phenomena of jointing and faulting—or, as our author prefers to express it, the effects of constant readjustment of blocks of the earth's crust to one another—are coming to be regarded as the essential factor in all great earthquakes. The interpretation of the phenomena of the past, by the study of forces in action at the present time, which is so fully recognised as the true principle of reasoning concerning the external agents operating on the earth's crust, is now felt to be equally applicable to the internal forces acting upon it. 'Seismic geology,' though divorced from Vulcanology, must still be regarded as one of the essential branches of Geological Dynamics.

In the earlier chapters of this work the author, inverting the usual method of treating the subject, deals with the evidences so familiar to the geologist of constant strain and intermittent fracture within the earth's crust, and demonstrates the existence of unstable belts where such conditions attain their maximum. He then shows

how the great earthquakes studied in recent years—the Mino-Owari (Japanese) earthquake of 1891, the Assam (Indian) earthquake of 1897, the Owens Valley (Sierra Nevada) earthquake of 1872, the Sonora (Mexican) earthquake of 1887, the Yukutat (Alaska) earthquake of 1899, and the St. Francisco (Californian) earthquake of 1906—were all accompanied by manifest dislocations at the earth's surface along lines of fault.

But in addition to this connexion between great lines of faulting and the occurrence of earthquake shocks—a connexion now generally accepted by geologists as definitely proved—the author, following up and extending the recent work of De Montessus, argues that innumerable lines of minor strain and fracture ('seismotectonic lines') can be detected by means of a study of dislocations on railways, the occurrence of 'craterlets,' and similar evidences of surface disturbance. The manner in which this kind of evidence is employed in seismological investigation has been illustrated in the case of the Charlestown earthquake by a paper published by Professor Hobbs in the Geological Magazine (May, 1907, Dec. V, Vol. IV, p. 197). The results obtained are networks of intersecting lines, which can often be shown to coincide with the existing features ('lineaments') of the district. Examples of 'seismotectonic maps' constructed on this principle are given in chapters vi and vii, including Ischia, Japan, California, the Greater Antilles, Scotland, the eastern United States, the Charleston area, etc., and the existence of such minor lines and their connexion with the surface features of the district is a question well worthy of the consideration of all geologists.

Chapters viii to xii, giving clear but condensed accounts of great earthquakes, especially those of the United States, cannot fail to prove of great service to all students of the subject. The essential and significant details are admirably sifted out from the often confused, trivial, and irrelevant materials of the original descriptions; and many subjects, like the modifications produced in the flow of underground waters, and the emission of 'sulphurous vapours,' with other minor phenomena, receive judicious treatment. The same praise may be awarded to the chapters dealing with the modes of studying the evidences of disturbance by earthquakes on the land and beneath the sea (chapters xiv and xv).

It is only after the geological aspects of the subject have been fully discussed that the author comes to the study of earthquakes by instrumental means, and proceeds to the discussion of the principles, the construction, and the modes of use of seismoscopes, seismometers, and seismographs. The reader will find in chapter xvi a very intelligible account of all the more recently invented types of apparatus now employed in the study of earthquakes. In his remarks on the relative values and applicability to different conditions of the various instruments, there is one very important point which has been overlooked by the author. As he justly states, all forms of seismograph suffer, and always must suffer, under the disadvantage that pendulums of every kind have a vibration of their own, dependent upon their length, and hence the movement of the earth's surface is complicated with that proper to the pendulum. By the employment

in conjunction, and side by side, of pendulums of very different lengths, and by the use of various systems of damping, this disadvantage may be diminished, though it can never be quite overcome. Hence the seismological observatory which has installed in it the most numerous and most varied types of instrument may be expected to obtain the best and most complete records. But there is another and very practical consideration that must also be kept in view. Not only is it desirable that the most delicate observations should be made at a particular spot, but it is equally important that records should be obtained at numerous and widely distributed stations, by means, if possible, of instruments of the same pattern, the records of which can be directly compared. In the selection of an instrument suitable for this work, it becomes absolutely imperative that the original price should not be so great as to make it prohibitive, and that the cost of maintenance (including photographic materials, etc.) should not be excessive. It is these considerations which have necessarily governed the action of the Seismological Committee of the British Association in the work they have carried on for so many years, and by their observance the Secretary of the Committee, Professor John Milne, has been able to establish and to keep maintained some forty seismological stations scattered all over the globe. The only reference to the Milne instrument in this work is a remark on the small amount of magnification of the movement of the earth particle in that instrument, and the author does not appear to be aware that this defect has already been removed by an addition to the instrument made by Professor Milne himself.

The Seismological Committee of the British Association can point with confidence to the important results obtained through the use of this instrument of Professor Milne's during the last twelve years. It has been asserted that an instrument of the Milne type, established at Strasburg, has not given satisfactory results. But how far this may have been due to want of proper adjustment or other causes is somewhat doubtful. The important point to be remembered is that a very large part of our knowledge concerning the distant effects of earthquakes, since the original work of Von Rebeur-Paschwitz, has been obtained by a comparison of the records obtained with the Milne instrument at widely distant stations. The author of this work, in his references to the labours of Professor Milne, is so fair and appreciative that we feel sure any seeming neglect of results obtained during eighteen years in Japan and twelve years subsequently at Shide must be due to misinformation and certainly not to personal prejudice or ill-will. We can very heartily recommend the work as giving a full and very clear account of the recent developments of what the author not inappropriately calls the New Seismology, dealing with the observations of earthquakes at a distance, and the conclusions to be drawn from such observations.

J. W. J.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*January 22nd*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Origin of the Pillow-Lava near Port Isaac in Cornwall." By Clement Reid, F.R.S., F.L.S., F.G.S., and Henry Dewey, F.G.S.[1]

The Upper Devonian strata around Port Isaac consist of marine slates, in which occurs a sheet of pillow-lava over 200 feet in thickness. The pillows measure usually from 2 to 5 feet in diameter, but range up to 8 feet; masses under 1 foot are rare. The individual pillows are quite disconnected, although moulded on one another and adherent where they touch. Where three pillows approached there was an angular vacant space, subsequently filled with calcite, which is often altered into chert. Their mutual relations seem to prove that they were soft when deposited, but not sufficiently soft to squeeze into corners.

Each pillow shows internally a central vacant space or very open sponge, often as much as two feet in length. This is succeeded by a thick shell of exceptionally vesicular lava, which is followed by an outer shell of banded, more or less, vesicular rock. The whole mass is so vesicular that it must have been very light.

If this lava were subaërial, the lightness would not help us to explain the origin of the isolated pillows; but the intimate association with fine grained marine strata shows that it was probably submarine. On calculating the proportion of cavity to rock in two of the pillows, the authors find that the specific gravity of the whole mass must have been very low, not greatly exceeding that of sea-water. The lava seems to have been blown out into thick walled bubbles, kept from touching each other by the escaping steam. The whole mass was for a short time in the spheroidal state, and, although composed of a multitude of large plastic spheres, the sheet could flow like a liquid. This eruption seems to have been analogous to that of Mont Pelé, described by Dr. Tempest Anderson and Dr. Flett, except that it was submarine instead of subaërial.

2. "On the Subdivision of the Chalk at Trimmingham (Norfolk)." By Reginald Marr Brydone, F.G.S.

The object of this communication is to lay before the Society a sketch-map showing the geographical distribution of the sub-divisions, with a brief account of their distinguishing features. Practically the whole of the Chalk exposed on the foreshore comes under the two main divisions—one composed of (*a*) Sponge-beds, very largely yellow, 12 feet, resting on 8 feet of White Chalk; (*b*) White Chalk without *Ostrea lunata*, about 9 feet thick; (*c*) White Chalk containing *O. lunata*, 20 feet; and the other composed of (*a*) Grey Chalk, about

[1] Communicated by permission of the Director of H.M. Geological Survey.

12 feet thick; succeeded by (*b*) White Chalk with *Ostrea lunata*, about 20 feet; (*c*) White Chalk without *O. lunata*, about 8 feet; (*d*) White Chalk with *O. lunata*, about 10 feet; and (*e*) Grey Chalk, about 25 feet. There is no evidence as to the relative positions of these two main divisions. The author seeks to justify his adoption of *Terebratulina gracilis* and *T. Gisei* as the zone fossils of the Trimmingham Chalk, in opposition to the proposal to adopt *Ostrea lunata* as the zone fossil. Other important species are *Pentacrinus Agassizi*, *P. Bronni*, and *Echinoconus Orbignyanus*. The author still adheres to his view that these masses of Chalk can only be *in situ* and must have once formed part of a large continuous mass, and that the bulk of this mass must have lain to seawards of the present coast-line.

II.—*February 5th*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "On Antigorite and the Val Antigorio, with Notes on other Serpentines containing that Mineral." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.G.S.

It is by no means certain, as the author ascertained after his joint paper with Miss Raisin, published in 1905, that the first described specimen of antigorite was really found in the Val Antigorio. So last summer he visited that valley, in company with the Rev. E. Hill, and after an examination, of which he gives an account, came to the conclusion that the rock most probably does not occur there *in situ*, though it is found in pebbles, etc., from tributaries.

He next describes other specimens of antigorite serpentine, examined since 1905; some from New Zealand, kindly sent to him by Dr. J. M. Bell, and others obtained in the Saasthal, especially from the Langefluh; giving further particulars about specimens in the National Collection at South Kensington and in the University Collection at Cambridge.

He then discusses the origin of the mineral. Pressure is apparently essential; certainly it can be formed from augite, and, though he has not discovered residual olivine in his own rather numerous specimens, or typical antigorite in Alpine bastite serpentines, he finds indirect evidence of its coming from this mineral, proofs of which are given by F. Becke, M. Preiswerk, and J. M. Bell. If, however, we suppose the former existence of two types of peridotite in the Alps, as at the Lizard and in the Vosges, and pressure sometimes to have preceded, sometimes to have followed serpentinization, we can account for the apparent conflict of evidence.

2. "The St. David's Head 'Rock Series' (Pembrokeshire)." By James Vincent Elsden, B.Sc., F.G.S.

The St. David's Head and Carn Llidi intrusions are of complex composition, ranging from a basic biotite-norite to an acid quartz-enstatite-diorite, and finally to soda-aplite. Throughout all the types, except the last, there is a high magnesia percentage. The extreme types sometimes pass abruptly one into the other, and at other times

they are mixed in various proportions. They do not represent a composite intrusion, but simultaneous intrusions of an imperfectly-mixed magma. There is no evidence of differentiation *in situ*, but the facts suggest a common origin from a differentiated magma-basin. The aplite-veins may represent the most acid phase of the differentiated magma.

Petrographically the rocks are of considerable interest, as exhibiting types not very commonly occurring in the British Islands. They also afford unusual facilities for the study of both rhombic and monoclinic pyroxenes, and appear to throw light upon the origin of the sahlite-striation of the latter. Rhombic pyroxene generally crystallized earlier than the monoclinic pyroxene, but sometimes these relations are reversed, and often the two forms are crystallographically intergrown, sometimes as twins. There are two distinct varieties of augite, distinguished by the presence or absence of a basal striation. The relation of these two types lends support to the perthitic theory, that there is an ultra microscopic crystallographic intergrowth of rhombic and monoclinic pyroxene. The probable age of the intrusions is not greater than that of the earth movements which folded the Arenig Shales in this district. The observations recorded in the paper seem to point to the conclusion that acid streaks and cores in basic igneous rocks may not always be due to differentiation *in situ*.

II.—Mineralogical Society.

November 12th, 1907.—Professor H. A. Miers, F.R.S., President, in the Chair.

On hopeite and other zinc phosphates and associated minerals from Broken Hill Mines, North-Western Rhodesia; by L. J. Spencer (Geol. Mag., 1907, p. 379). Hopeite is abundant as brilliant water-clear crystals or as larger white crystals reaching 2 cm. across. The crystals are orthorhombic with $a : b : c = 0{\cdot}5786 : 1 : 0{\cdot}4758$. Cleavage flakes parallel to the brachypinacoid show a zonal intergrowth of two substances, distinguished as α-hopeite and β-hopeite: these differ considerably in their optical characters, and slightly in sp. gr. (3·0—3·1) and the temperature at which water is expelled. Associated with the hopeite crystals on the bone-breccia are brown botryoidal masses of vanadinite. The other zinc phosphates occur, not in the bone cave, but with cellular limonite and crystals of descloizite and pyromorphite in connection with the zinc-lead ores (which consist of an intimate mixture of cerussite and hemimorphite with interspersed limonite). The new species *tarbuttite* occurs in great abundance, and is a basic zinc phosphate, $Zn_3P_2O_8 . Zn(OH)_2$, with sp. gr. 4·15: the crystals are anorthic with $ac = 55° 50'$, $ab = 84° 34'$, $bc = 76° 31'$, c being a direction of perfect cleavage. Pseudomorphs of tarbuttite after calamine ($ZnCO_3$), descloizite, and hemimorphite are not uncommon. Another new species, named *parahopeite*, has the same chemical composition as hopeite, $Zn_3P_2O_8 . 4H_2O$, but is anorthic with sp. gr. 3·31. The platy crystals somewhat resemble hemimorphite in appearance; they have one perfect cleavage, approximately

perpendicular to the plates, through which emerges one of the optic axes.—The question of a relation between Isomorphous Miscibility and Parallel Growths; by T. V. Barker. A study of the growths on each other of immiscible or slightly miscible pairs of substances has shown that although miscibility and parallel growths are favoured by the same factor—similarity and molecular volume—yet the two properties do not always go hand in hand: for many immiscible or only slightly miscible substances form parallel growths quite readily. Mixed crystals, therefore, should not be regarded as built up of alternating parallel layers.—Notes on zeolites from Cornwall and Devon; by A. Russell. The occurrence of zeolites in various localities was described, e.g. that of heulandite near Okehampton, stilbite at Botallack and St. Ives, chabazite at Luxullian, apophyllite and analcite at Lostwithiel.—Note on the crystallisation of potassium bichromate; by Professor H. A. Miers. Two stages of growth of potassium bichromate crystallising from a drop of solution were described and illustrated by lantern slides.—On various minerals from the Lengenbach quarry and the Ofenhorn, Binnenthal; by R. H. S. Ily. Crystals of binnite, one of them a unique twin, and examples of the regular intergrowth of sartorite and baumhauerite were described, and the occurrence of brookite and molybdenite on the Ofenhorn was for the first time recorded.—Mr. L. J. Spencer exhibited on behalf of Dr. H. J. Johnston-Lavis some minute crystals of hæmatite found in association with chlormanganokalite in blocks ejected from Vesuvius during the eruption of 1906. The crystals have the form of acute scalenohedra $\beta\ \{313\} = \{2461\}$. A fine series of zeolites from the neighbourhood of Belfast was shown by Mr. F. N. A. Fleischmann, a new meteoric stone from Simondium, Cape Colony, by Dr. G. T. Prior, specimens of reconstructed ruby and blue spinel, and of the new gem benitoite, by Dr. G. F. Herbert Smith, and a specimen of artificial hæmatite by Mr. C. J. Woodward.

CORRESPONDENCE.

NOTES ON FOSSIL PLANTS FROM SOUTH AFRICA: A CORRECTION.

SIR,—In the description of *Phyllotheca Whaitsi*, sp. nov., on p. 181 of my "Notes" the locality of the specimen found by Mr. Whaits is given as "Prince Albert in shale lying between the Witteberg Series and the Dwyka conglomerate." I am indebted to Miss Wilman, of Kenilworth (Cape Town), for pointing out to me that the locality should be described as Farm Klipfontein, Fraserburg District, a well-known locality of fossil reptiles. The strata form part of the Beaufort Series, and are probably of Permian age. Miss Wilman's correction is confirmed in a letter from Mr. Whaits.

A. C. SEWARD.

BOTANY SCHOOL, CAMBRIDGE.

RADIOLARIAN ROCKS OF THE CULM MEASURES, DEVONSHIRE.

SIR,—I wish to call attention to the unfortunate mistake which I have made on pp. 4, 105, 106, 107, 108, and 109 of the Geological Survey Memoir on Plymouth and Liskeard, 1907, in attributing to Mr. Fox alone various statements which I have quoted from the joint papers of Messrs. Hinde and Fox on the Radiolarian rocks of the Culm Measures, in the Quart. Journ. Geol. Soc., vol. li, 1895, and in the Transactions of the Devonshire Association, vol. xxviii, 1896, and in Proc. Geologists' Association, vol. xx, pp. 88, 92, 1907. I desire to express my regret, and to offer my apologies to these authors for the unintentionally deficient references to their joint papers.

W. A. E. USSHER.

28, JERMYN STREET, S.W.
February 12th, 1908.

THE LIQUID AND PNEUMATOLYTIC THEORIES OF GRANITIC MINERALS.

SIR,—I have noticed with much regret that the conclusions arrived at by the Geological Survey[1] as to the crystallisation of the West Country Granites are in hopeless conflict with several communications which the GEOLOGICAL MAGAZINE has honoured me by publishing.

Broadly speaking, the Survey authorities have adopted the high temperature gaseous theory,[2] whereas I have assumed the impregnability of the low-temperature liquid theory. Any attempt at reconciliation is useless, but it may be as well if I submit the list of the authorities on which I have relied. They are in order of date as follows:—

(1) Sorby, "Microscopical Structure of Crystals": Q.J.G.S., 1858.
(2) Sorby & Butler, "Rubies, Sapphires, and Diamonds": Proc. R.S., 1869.
(3) Hartley, "The Identification of Liquid Carbonic Acid in Mineral Cavities": Royal Micro. Soc., March 1st, 1876.
(4) Sorby, "On the Critical Point in the Consolidation of Granitic Rocks": Mineralogical Mag., September 6th, 1876.
(5) Hartley, "On Variations in the Critical Point of Carbon Dioxide in Minerals," etc.: Journ. Chem. Soc., September, 1876.
(6) Hartley, "Observations on Fluid Cavities": Journ. Chem. Soc., March, 1877.
(7) Hartley, "Attraction and Repulsion of Bubbles by Heat": Proc. R.S., 1877.
(8) Hartley, "On the Constant Vibration of Minute Bubbles": Proc. R.S., 1877.
(9) Report on the Conditions under which Liquid Carbonic Acid exists in Rocks and Minerals, by a Committee consisting of Walter Noel Hartley, F.R.S.E., E. J. Mills, D.Sc., F.R.S., and W. Chandler Roberts, F.R.S. Drawn up by W. N. Hartley, F.R.S.E.: Rep. Brit. Assoc., 1877.
(10) A. Daubrée, "Etudes Synthétiques de Géologie Expérimentale": 1879.
(11) Sorby: Address to the Geological Section of the British Association, 1880.
(12) Fouqué et Lévy, "Synthèse des Minéraux et des Roches": 1885.

I am bound to admit that the first chapter of Daubrée's "Experimental Geology" justifies the views of the Geological Surveyors, and

[1] "Land's End District," pp. 49–60, 1907.
[2] "'Pneumatolysis' refers to the action of gases above critical temperature" ("Falmouth and Camborne," p. 168, 1906).

that Fouqué & Lévy do not directly challenge them. It will, however, be noticed that the papers of Dr. Sorby and Professor Hartley, published as they are in the records of Societies such as the Royal, Chemical, Microscopical, and Mineralogical, and in the Reports of the British Association (and published, moreover, quite independently, and for different objects of research), might very well not have all come under the notice of MM. Daubrée, Fouqué, and Lévy; and that indeed seems to have been the case.

Speaking for myself, I certainly should not have seen most of the above papers had not the authors most generously sent me reprints.

I am certainly in a great difficulty. One of the minerals relied on by the Geological Survey to prove pneumatolytic action at temperatures above the critical temperature of water is topaz. But, in Professor Hartley's paper on Fluid Cavities to the Chemical Society in 1877, one section is entitled "On the Probable Temperature incident to the formation of Topaz," and one conclusion arrived at is that topaz sometimes crystallises under and sometimes over the C.T. of water.

The petrologists dismiss all the evidence relied on by the chemists for ascertaining the temperatures of rock-formation. But there is this fact to be borne in mind, that while the chemists have minutely studied separate minerals, the petrologists have taken a wider view of rocks and magmas.

The following example will serve to show how widely eminent petrologists and chemists differ as to probable temperatures. Professor Hartley, in discussing the formation of negative cavities in quartz, observes:—"The mineral is crystallised at a high temperature, say 150° C." (on Fluid Cavities).[1] The theory adopted by the Geological Surveyors often necessitates a temperature exceeding 365° C.

Since the publication of the Cornish Memoirs I have for the first time understood the irritation that my unfortunate little papers have naturally caused. St. Paul hits the position off exactly: "If I know not the meaning of the voice, I shall be unto him that speaketh a barbarian; and he that speaketh shall be a barbarian unto me."

I can assure my geological friends that for very many reasons I most deeply regret ever having published outside the provinces anything on the subjects of either Petrology or Ripplemark; as both subjects have led to a vast amount of genuine misunderstanding and discomfort, and I may add of mystification; and they are not worth it.

A. R. Hunt.

ORIGIN OF THE SUDBURY NICKEL ORES.

Sir,—In Professor Coleman's interesting restatement of what he regards as "incontrovertible proof" of the igneous origin of the Sudbury nickel ores, he makes the safe assumption that I had not seen the long announced second part of his monograph (Report of the Bureau of Mines, Ontario, vol. xiv, No. 3). It would be inexcusable for anyone to discuss the Sudbury mining field without

[1] Reprint, p. 8.

careful consideration of any work that Professor Coleman had published on it. I am not aware that his second report was available when I prepared my address. Its issue was reported in *Economic Geology* for June, 1906; but as the paper is not included in the Annual List of Literature received by the Geological Society for either 1905 or 1906, I presume *Economic Geology* was supplied with an advanced copy. This view is supported by the fact that Professor Coleman, in a paper in the Journal of Geology for last month, published six months after the manuscript of my address had to be in the hands of the printer, refers to his report as "recently distributed." I notice, moreover, that there is no reference to it in Messrs. Campbell & Knight's paper on the Microstructure of the Nickeliferous Pyrrhotites, which was received in this country after my address had been delivered. As the report was apparently inaccessible to American authors, it is not surprising that it was not available on this side of the Atlantic.[1]

My opinion as to the origin of the Sudbury ores is not so emphatic as Professor Coleman's article would suggest. The opinion which he quotes was introduced by the words "appear to have been," and the next sentence continues the same expression of doubt—"if Dickson's facts be right," etc. Without having been in the field, I should be sorry to express a final opinion on either side. But so far as I am capable of judging from the literature, the igneous origin of the ores is not yet established, and is faced by greater difficulties than the alternative theory. Messrs. Campbell & Knight, in their recent paper in *Economic Geology* (June, 1907), also conclude that "Dickson has a weight of evidence to prove that his specimens are of secondary aqueous origin" (p. 351). They claim that (p. 365) in all the chief mining fields of nickeliferous pyrrhotite the mode of origin of the ores was the same, and that the basic rocks with which the ore bodies are associated were first formed, then fractured, and then "ore-bearing solutions came in and replaced the rock-matter wholly or in part by pyrrhotite. Later on the pyrrhotite, etc., was also strained and broken, and the deposition of pentlandite and chalcopyrite followed." Hence I am not the only one who is not yet convinced that the igneous origin of these ores is "the correct view."

J. W. Gregory.

Geological Department,
University, Glasgow.
January 31*st*, 1908.

KITCHEN-MIDDENS IN NORTH CORNWALL.

Sir,—In Mr. B. B. Woodward's interesting paper in the Geological Magazine (January and February, 1908) on "The Drift and Underlying Deposits at Newquay," he mentions kitchen-middens and cooking-sites as occurring towards the upper parts of the deposit of sand (Fig. 1, p. 15, January). It may be interesting to note the similar occurrence in the Trevose district further to the north-east of many such kitchen-middens and cooking-sites. In October, 1901

[1] I am informed (Feb. 17th) that Professor Coleman's report has not even yet been received at the Geological Society's Library.

(in company with Mr. G. Bonsor, Dr. Thelwell, and Mr. Mallett) we found in the blown sand above the cliff near Constantine Island many traces of hearths, at different levels, down to a depth of 8 feet from the highest point of the midden. There were charcoal, burnt bones, and shells of *Patella vulgata*, *Cardium edule*, and *Mytilus edulis* (some showing traces of the action of fire on them). The fact of the differing levels of these hearths seems to show a prolonged occupation of the Trevose peninsula by Neolithic man or his descendants in the Bronze or early Iron ages. There is an extensive circular midden round Constantine Church (ruins), there are others covered with blown sand that can be identified by the shells and bones turned out by rabbits in making their burrows. Also an extensive midden occurred at the Harlyn Bay late Keltic burial-ground. I say occurred, because it has been levelled and planted with trees. From that kitchen-midden were obtained teeth of *Bos taurus*, *Sus scrofa*, and shells of *Mytilus*, *Patella*, *Helcion*, etc., and quantities of broken *Purpura lapillus*, which Mr. Santer Kennard, F.G.S., considered were thus broken to extract colour for dyeing. I cannot verify the reference, as I do not keep the *Illustrated London News*, but, as far as I remember, Mr. George Bonsor, whose discoveries near Carmona have given him a European reputation, found somewhat similar conditions as to kitchen-middens and cooking-sites near St. Mary's in the Scilly Isles, but, so far as I know, his paper on this work has not yet appeared.

R. Ashington Bullen.

Woking.
February 5th, 1908.

OBITUARY.

BERNARD J. HARRINGTON, B.A., Ph.D., LL.D.

Born August 5, 1848. Died November 24, 1907.

We regret to record the death of Dr. B. J. Harrington, who was formerly chemist and mineralogist to the Geological Survey of Canada, and subsequently Professor of Mining and also of Chemistry in McGill University, Montreal. Born in the province of Quebec he was educated at McGill University, and afterwards graduated Ph.D. at Yale. In 1872 he succeeded Dr. T. Sterry Hunt as chemist and mineralogist to the Canadian Geological Survey under Selwyn. To the publications of that Survey he contributed reports and analyses of coals, iron-ores, and sundry minerals. He also prepared a catalogue of the Canadian minerals, rocks, and fossils exhibited in the Paris Exhibition of 1878. He described the new mineral Dawsonite (1874), wrote on the microscopic structure of dykes cutting the Laurentian rocks (1877), and on the minerals of some of the apatite-bearing veins of Ottawa County (1879). In later years he contributed papers on mineralogical subjects to the Transactions of the Royal Society of Canada, the American Journal of Science, and other journals. He had been President of the Chemical and Physical Section of the Royal Society of Canada, and he was appointed a Vice-President of

the Chemical Section of the British Association at the meeting held in Toronto.

Dr. Harrington was perhaps most widely known in this country as author of the interesting "Life of Sir William E. Logan," which was published in 1883.

ROBERT LAW, F.G.S.

Born June 21, 1840. Died December 29, 1907.

The late Mr. Robert Law, whose death took place at the close of last year, was in many respects a remarkable man. Born at Walsden in Lancashire, on the borders of Yorkshire, he commenced the business of life as a weaver, but was attracted in his leisure hours to the local Working Men's Club and Institute, where his interest was aroused in the Natural History and Archæology of his neighbourhood. Although at the time he was regarded as "a very rough, unpolished diamond," yet, after passing through a course of instruction in what may be called elementary subjects, he became passionately devoted to the study of geology, spending what little spare money he had on books and fossils, and his spare time in reading or in tramping the district for miles around. In this way he became so proficient in geological science that he was recognised as its leading exponent in the country round Walsden. He soon widened his sphere of operations, his wanderings taking him to the Mountain Limestone districts of Castleton, Derbyshire, to Clitheroe in Lancashire, and to the Lias of the Yorkshire coast.

About 30 years ago he commenced his first class in geology at Todmorden, under the auspices of the local Science and Art Committee, and in the same year he had a similar class at the Institute at Walsden. By virtue of his position as a teacher, Mr. Law had the privilege of attending several of the Summer training courses in geology and kindred subjects at the Normal College of Science, South Kensington. He had a plain but effective method of teaching, and possessed to a remarkable degree the power of winning the interest and devotion of his students. In a few years he was in very great demand as a teacher, and had classes every evening in the week, as well as on Saturday afternoons. Among the places at which he taught were Bacup, Rochdale, Shaw, Oldham, Hebden Bridge, Halifax, and Lightcliffe.

His friend Mr. Walter Baldwin, of Rochdale, remarks in a letter that "as a lecturer he had a style peculiar to himself and one which took with the working-men, as he never lost his Yorkshire accent, which certainly was a strong one. He and the late Mr. James Horsfall, of Rochdale, were the first to draw attention to the minute flint implements from the Lancashire and Yorkshire Moors." They brought a paper on the subject before the British Association at Montreal. The same authors read before the Manchester meeting of the Association in 1887, a paper "On the discovery of Carboniferous Fossils in a Conglomerate at Moughton Fell, near Settle, Yorkshire" (see Geol. Mag., 1888, p. 30).

If not one of the actual founders, Mr. Law was one of the early, most active, and notable of the leading men connected with the now defunct Todmorden Scientific Association, and regularly took his part in the lectures and debates. He was elected a Fellow of the Geological Society in 1886.[1]

ARTHUR BEAVOR WYNNE.

Born October, 1835. Died December, 1906.

A. B. Wynne, an energetic and enthusiastic geologist, was in 1855 appointed an Assistant Geologist on the Geological Survey of Ireland, under Jukes, and was engaged in surveying chiefly in counties Tipperary, Waterford, and Cork.

Resigning his post in 1862, upon being appointed on the staff of the Indian Geological Survey, he laboured zealously for eleven years in the neighbourhood of Bombay, and in the Punjab, working at the stratigraphy of the Salt Range, and at the problems of mountain-building.

Ill-health compelled him in 1883 to retire from his work in India, but in the same year he temporarily rejoined the Geological Survey in Ireland, to take charge of the Office work. Here he continued to labour until 1890.

He was for many years a supporter and frequent contributor to the pages of the Geological Magazine, taking part in 1867 in the great discussion on Denudation, when he utilized both his Irish and Indian experience. Occasionally he signed a letter in Indian characters, as when writing in 1875, on the inverted strata of the Mendips. To the Memoirs of the Geological Survey of Ireland and India he contributed the results of his field work; while other of his papers were published by the Geological Society, and by the Royal Geological Society of Ireland, of which he was President in 1889.

MARK STIRRUP, F.G.S.

Born 1831. Died June 10, 1907.

A zealous member of the Manchester Geological Society, Mr. Stirrup had communicated to that body the results of observations on the Glacial Geology of Llandudno (1883), and on the effects of Marine Erosion as shown by the Sea-Cliffs and Sea-Caves of the British Isles (1897). He also wrote an account of the early history of that Society (1897).

To the Geological Magazine he communicated in 1885 a translation of Charles Brongniart's important paper on the Fossil Insects of the Primary Rocks. In 1890 he wrote on Wind-Waves and Tidal Currents, drawing attention to Hermann Fol's observations on the movements of water, made, whilst engaged in diving, at depths of more than 100 feet in the Mediterranean. The true Horizon of the

[1] The above remarks are mainly taken from the *Rochdale Observer*, Jan. 4th, 1908.